Sky and TELESCOPE

In This Issue:

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Vol. III, No. 5
MARCH, 1944
Whole Number 29
25 cents

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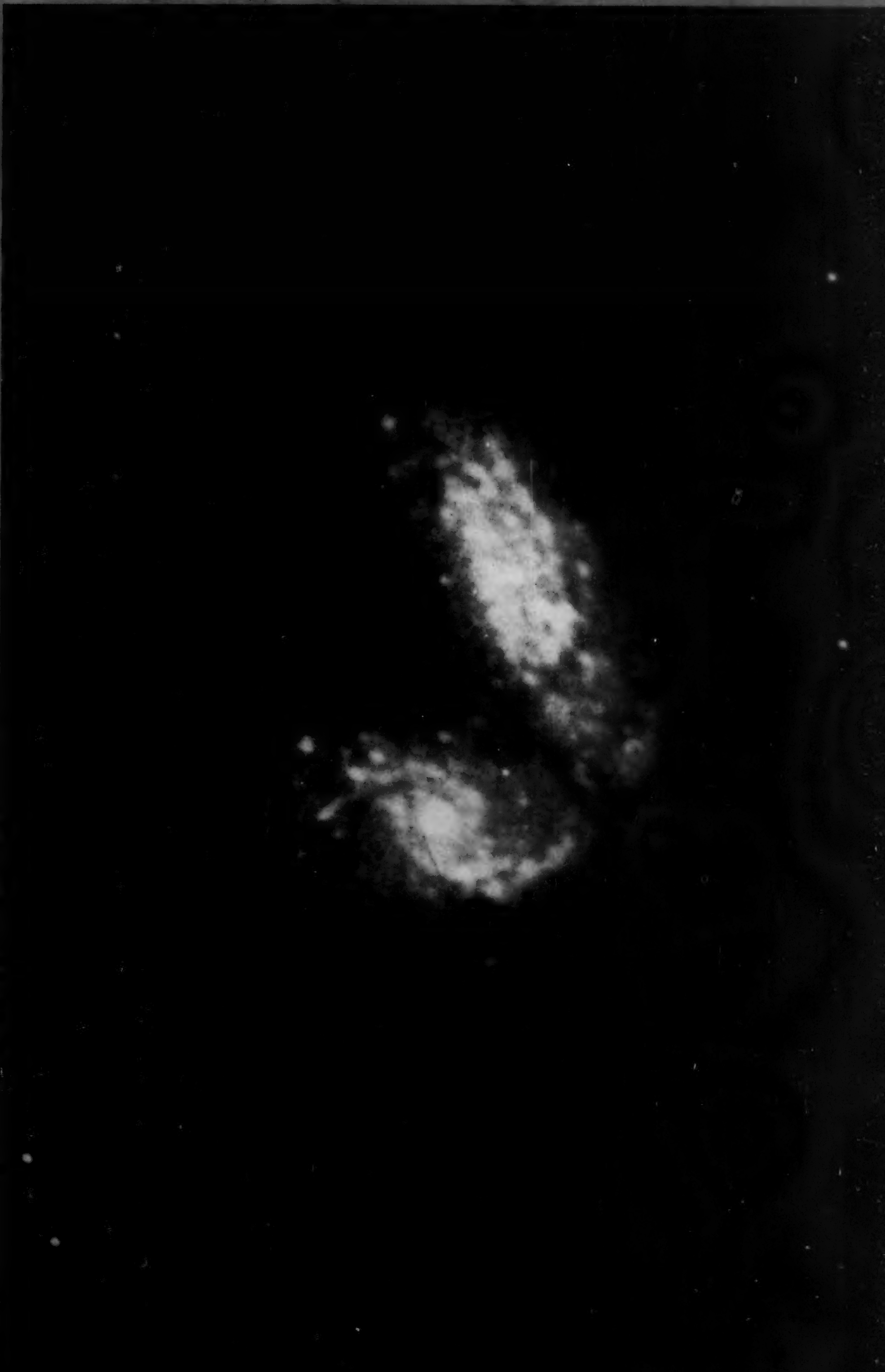

A twin spiral system in Virgo

OCCULTATION REPORTS

THE OCCULTATION of Jupiter on January 13th was observed under generally favorable conditions in the eastern and central parts of the United States, although in places clouds interfered. The editors will suppress their natural tendency to expand on the glory of viewing the magnificent spectacle of the planet, three satellites, and moon in the 7½-inch Clark refractor at the Harvard Astronomical Laboratory, with perfect observing conditions, and present excerpts from the enthusiastic reports by many readers.

Loraze B. Taylor, of Indiana University, Bloomington, Ind., recalls that "the ancients must have felt some fear of an actual collision of the heavenly bodies when they observed such a phenomenon." She goes on to say:

"I had a richest-field telescope to facilitate observation and the back bedroom with the window open made a pleasantly warm observatory; of course, the image wavered slightly, but it was preferable to my violent shivering outdoors which would have made it impossible to hold steadily this unmounted telescope.

"Upon arising at 6:15 (C.W.T.) I took a hasty look at the approaching pair and decided they appeared to be only about five minutes apart despite predictions of a much later time. I glued an eye to the eyepiece and waited—and waited. Some 10 minutes later they were but little closer, so I warmed myself at the fireplace; then I made a sketch of the moon as seen through the 6-inch reflector. It looked like an artificial globe with the pole (Tycho) and meridians all laid out.

"Contrary as the ping pong ball he resembled, Jupiter avoided making his disappearance as long as possible, and some minutes after he was invisible to my naked eye, he had still not touched the moon in the telescope. This effect was probably due to the difficulty of readjusting my eyes after looking through the telescope, or perhaps to a sensitivity to glare which I experience. This may have accounted for my complete failure to see the satellites in the telescope near the brilliant

(*Continued on page 19*)

NOTICE

EFFECTIVE with new subscriptions ordered after March 1st, and with renewals ordered after April 1st, the price of Sky and Telescope is increased to $2.50 per year for the United States and possessions, including service men and women overseas; to $3.00 per year for Canada and countries in the Pan-American Postal Union; and to $3.50 per year for all other foreign countries. The single copy sales price is increased to 25 cents.

Current subscriptions expiring with the issue of March, 1944, and thereafter, will be billed at the new rates, but may be renewed at present rates until April 1st. All current subscriptions may be extended for any period at present rates before that date.

SKY PUBLISHING CORPORATION

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER, ***Managing Editor***

The Editors Note . . .

WHEN one of our best friends in Peru, R. Stuempfle, wrote to us early in January that he expected to be in Chiclayo on the 25th (only three hours by car from his home in Trujillo) we cabled him requesting that a report on the total eclipse of the sun as he observed it be sent by air mail. This report reached us in time to be printed in this issue, together with an enlargement of his original photograph of the corona, taken with a small camera, and a sketch in color.

The partial eclipse did not pass without notice. In Trinidad, P. Clem. Campariole was well prepared to observe, but he reports that the sky was overcast for most of the time. He observed the "notched" sun by projecting its image, and writes:

"The sun was quite obscured at first contact. At 9:55 (60° W. long. time) the sun was first seen and the moon was already well on. A small sunspot was observable near the eastern limb. Last contact was at 12:22:09, but this may be a few seconds out as, owing to bad reception, I could not get the radio time signal for checking until night time. My station is 10° 39′ 44″ N., 61° 31′ 24″ W."

Francis A. Wilmot, Qm2c, U.S.S. **Doyle**, who reported in May, 1943, on his "discovery" of Whipple's comet from shipboard, writes of his "good fortune to be able to observe a partial phase of the total eclipse. Of course, it's impossible for me to divulge where I was at the time. I only wish that I had been more appropriately stationed in the totality belt. As before, I was somewhat the 'ship's astronomer' and made close observations of the phenomenon. I was gratified to note that my calculations for the contacts and maximum obscuration agreed with observation. Other than that, there was nothing spectacular. Indeed, many didn't even realize that an eclipse was going on!"

In Texas, it was cloudy!

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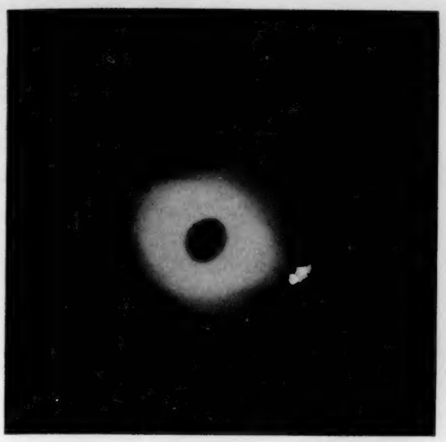
SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

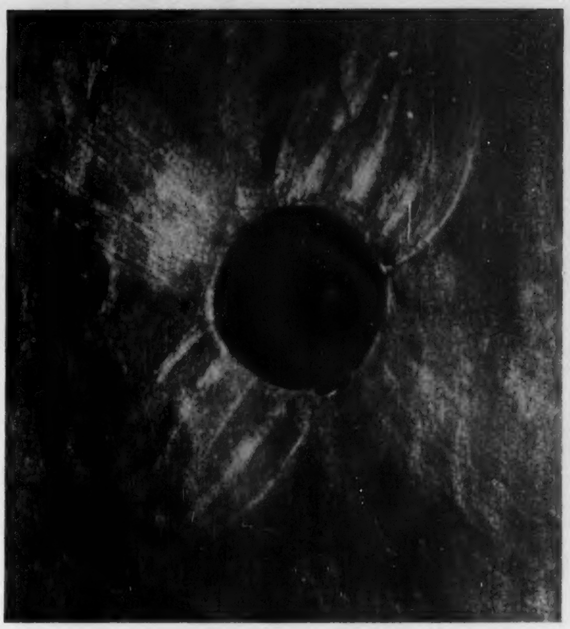
Subscription: $2.50 per year in the United States and possessions, and to members of the armed services; Canada and all countries in the Pan-American Postal Union, $3.00; all other foreign countries, $3.50. Make checks and money orders payable to Sky Publishing Corporation. Send notice of change of address 10 days in advance. Circulation manager: Betty G. Dodd.

Editorial and general offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, but we do not guarantee prompt editorial attention under present conditions, nor are we responsible for the return of unsolicited manuscripts unless adequate return postage is provided by the author.

Advertising director: Fred B. Trimm, 19 East 48th Street, New York City; ELdorado 5-5750.



The author's snapshot of the January 25th eclipse, airmailed from Peru, reveals the outer corona, and (right) a sketch made from visual observations shows the polar and equatorial streamers and two prominences.



An Eclipse Report

By R. Stuempfle

Trujillo, Peru

I LEFT Trujillo at 4:00 a.m. the morning of January 25th, and arrived three hours later in Chiclayo. The "equipment" with me was a 20-power theodolite from E. R. Watts & Son, London, and a Rolleicord f/4.5 camera; these I set up on the road to Pimentel, about 500 meters from Chiclayo and close to the camp reserved for the Mexican expedition [which apparently went to Chiclayo instead of Cajamarca]. The weather was hot and beautiful, with blue sky and no clouds.

My attention was limited to the visual observation of the phenomenon and I did not attempt to control or secure exact time. From the beginning of the eclipse to the moment of second contact, the fading luminosity, a pale gray color of the ground, and an intense blue-violet of the western sky were of interest. A small sunspot, observed since the 22nd, at about 80°, near the limb, disappeared at 8:54½.

During the 2¾ minutes of totality, the corona, soft and beautiful, of a pale greenish-white gloom, captures the admiration of anybody. In the north-south direction (not exactly), I distinguish a well-ribbed stream, the stripes of dark and clear sharply pronounced. East and west runs another band, larger, weaker, and nearly uniform without contrasts. A very pale square of faint coronal light with its corners resting in north, south, east, and west, seems to be the background of this impressive and quite symmetrical picture. Two big red prominences, at 225° and 315°, are visible. All too soon a beautiful "diamond ring" announces the end of totality.

I enclose the original film of the corona, 1/25 second at f/6.3, and I hope that convenient enlargement and paper will show good details. One of my friends, Alfredo Pinillos Goicochea, national deputy, took two rolls of moving pictures in colors, which have been sent by plane to Eastman Kodak for developing.

I enclose some reports of local newspapers with details from Cajamarca, San Miguel de Pallaques, and Chiclayo, with some interesting figures given by the Mexican expedition. Newspapers had previously published the exact time, corresponding to latitude 6° 45′ S. and longitude 79° 58′ W., as follows.

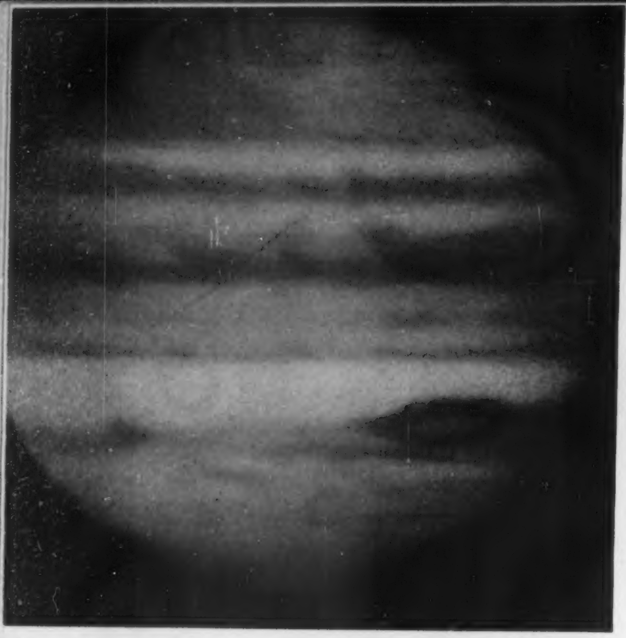
First contact:	7:56:08.0
Second "	9:07:22.9
Third "	9:10:09.5
Fourth "	10:33:51.7

Thus, the time calculated for totality was 167 seconds, but there is no doubt that it was observed to be only 160½ seconds. The exact times of second and third contacts have been checked by many people and nobody can explain the difference of 6½ seconds. The times announced by the Mexican expedition observers are [according to the press clippings enclosed]:

First contact:	7:56:29.5
Second "	9:07:36.5
Third "	9:10:17.0
Fourth "	10:33:03.0

When comparing this eclipse with the one in this country in June, 1937, many of my friends consider that the earlier eclipse was much more impressive than this one. Also, the darkness, and consequent visibility of the stars, was greater that time; well, I personally cannot testify as I saw the 1937 eclipse in Pataz and it was partial.

Mr. Stuempfle traveled from Trujillo to Chiclayo to get into the path of totality of the January eclipse. Map by Charles H. Smiley.



Jupiter and its banded atmosphere.

Our Planetary Neighbors

By William H. Barton, Jr.

Our fellow members of the solar system present many problems for study. What are they made of? How fast do they rotate? These and other questions are discussed here and in the Hayden Planetarium show for March.

"YES, BUT how do you know Venus rotates in about a month?" This and similar questions about the other planets are frequently asked. Strictly speaking, we do not "know" many of these things but we "believe" certain conditions exist. These beliefs are inferred from observed facts. Why do we say that Venus probably turns once in *about* 30 days?

A small telescope will show Venus as a crescent when viewed at the proper time. The outline will not be sharp, but hazy. If the planet is nearly between the earth and the sun, near inferior conjunction (the "new" phase), a narrow rim of light will extend completely around the disk of the planet. That is, the horns of the crescent extend farther around the disk than they should at this phase. The only possible explanation is that Venus has an atmosphere, a dense atmosphere.

Even under the most favorable conditions only vague markings can be observed on the bright surface of Venus. The use of infrared (haze penetrating) rays of light reveals little more; ultraviolet has been unexpectedly more successful, revealing irregular dark and light blotches which are definitely not permanent markings on the planet's surface. Rather they are cloud formations of only an ephemeral character. Special photographs made by Frank E. Ross with the large reflectors at Mount Wilson Observatory show daily alterations in these markings. Therefore, they are of little use in determining the rotation period of Venus.

The use of the spectroscope in determining the speeds of revolving double stars is familiar. Light from objects approaching us shows a spectral shift toward the blue; from objects receding, a shift toward the red; and in either case the amount of this Doppler shift is in proportion to the speed. If a planet is rotating, one edge is approaching us, while the opposite side is receding. Hence, the spectroscope might reveal the speed of rotation if a comparison of spectra taken from opposite edges of Venus is made. But no such shift can be detected, even by applying the most careful tests. The conclusion is that the planet rotates too slowly, and that it takes at least three weeks, perhaps a month, to turn once on its axis.

Mercury, we say, rotates and revolves in the same length of time, approximately 88 days. How do we know this? Here we have a planet that has no atmosphere. At times, a very slight atmosphere has been suspected. Certain careful observers, Schiaparelli and Antoniadi, have noticed the dark marks on Mercury obscured by cloud-like patches. This, however, cannot be accepted against the more positive fact that the reflecting power, albedo, of the planet is very low.

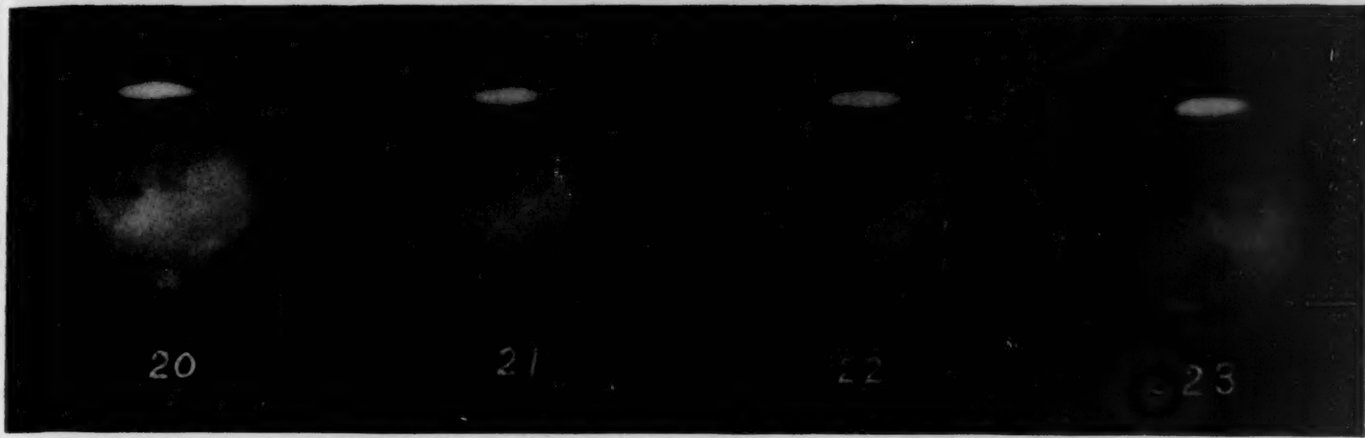
Mercury is a difficult planet to observe, since it is always relatively close to the sun. It is near the horizon after sunset or before sunrise, so it is best studied by telescopic means in full sunlight. Three great students have examined the surface of this world, and their sketches, while differing somewhat in details, agree in the main features. We have already mentioned Schiaparelli of Italy and Antoniadi of France. The third is the American, E. E. Barnard. All of their drawings show only a hemisphere, which would indicate that this half is the only lighted portion. Therefore, this one side always faces the sun, just as one side of the moon always faces the earth. Hence, the planet must turn on its axis in the same period in which it revolves around the sun.

This fact is confirmed by the temperatures of the two sides of the planet. One side, lit by the sun's rays and not protected by an atmosphere, has a very high temperature, as high as 770° Fahrenheit. The opposite side, in eternal night, and without the blanketing effects of an atmosphere, is believed to fall to a point near absolute zero. If there were an appreciable atmosphere, or if Mercury turned more rapidly, these temperature extremes would tend to equalize themselves somewhat.

If we examine a table of constants of the planets, we find that the rotation period of Mars is $24^h\ 37^m\ 22^s.654$. How can we state the period so exactly? Mars is the one planet on which we can see very distinct surface markings. This in itself is an indication of thin atmosphere—clear air rather free from clouds. Suppose then, that we should observe the planet tonight and at a certain instant of earth time find a well-marked spot exactly on the central meridian of the planet's disk. By observing on succeeding nights and by noting the gradual departure of this spot from the meridian, we could determine quite accurately the time required for one turn.

The above routine, with details that

Photographs of Venus near conjunction reveal (left) a bright cloud indicated by the arrow, and (right) the atmospheric ring completely encircling the planet. Photos by E. C. Slipher.



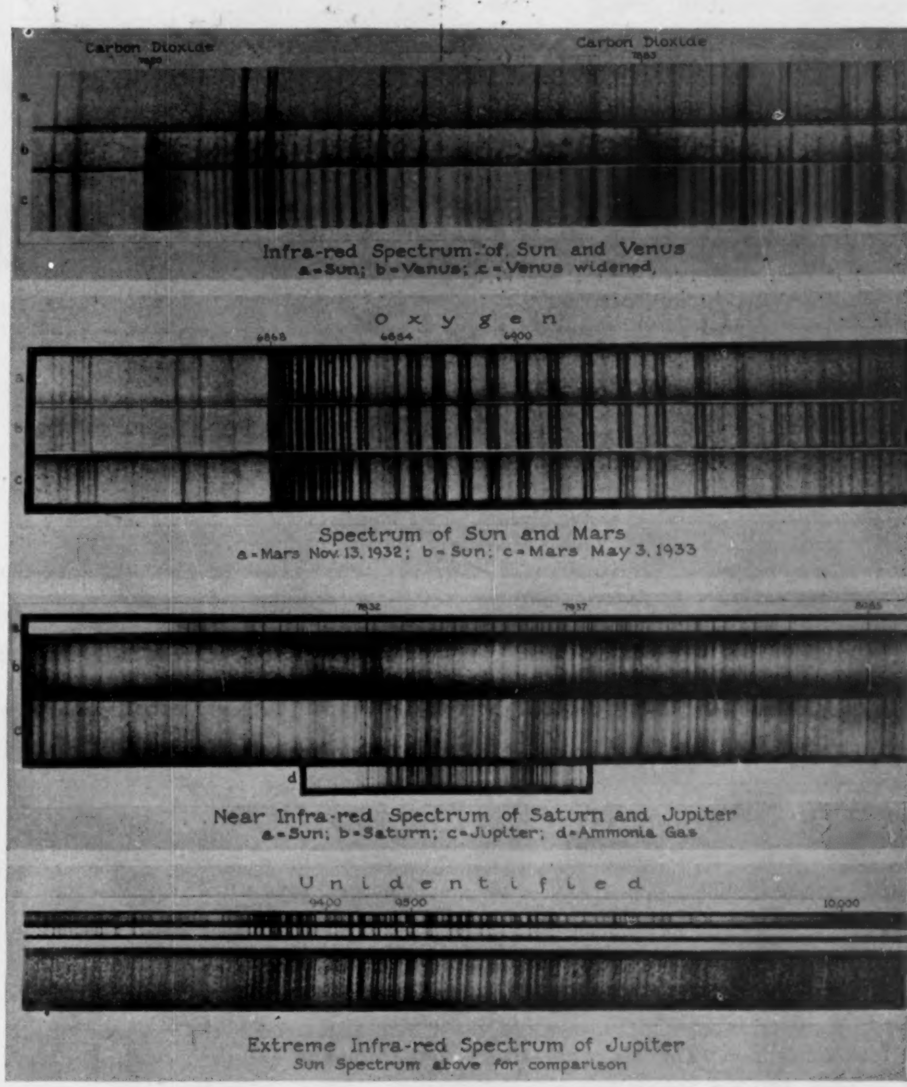
Images of Mars photographed by E. C. Slipher, of Lowell Observatory, in July at the 1939 opposition, show the daily changes in position of conspicuous markings, which provide a means for measuring the planet's period of rotation.

we need not consider here, has been performed so many times, over such a long interval, that a very accurate determination has been made of the planet's rotation period. We know this period more accurately than any other in all our family of planets except the earth itself.

The markings on the surface of Mars were first discovered in 1636 by Fontana, a Neapolitan astronomer. Two years later he found that a certain spot had reappeared, and from this concluded that the planet rotated. Hooke, too, studied the same problem and reached identical conclusions. He presented a paper on the subject to the Royal Society in 1666. He observed the recurrence of spots at the same place on the planet at regular intervals and concluded that the rotation period was either 12 or 24 hours. Cassini in Italy, at the same time, made an even better determination, for his figure was 24 hours, 40 minutes. Maraldi confirmed this, setting the period at 24 hours, 39 minutes, from studies he made in 1704.

In the autumn of 1719, there occurred a particularly favorable opportunity for verifying these figures. Observations of Mars are better made when the planet is near opposition, that is, when the earth is passing between it and the sun: the most favorable oppositions take place at intervals of 15 or 17 years, when oppositions occur which are near Mars' perihelion (nearest point in its orbit to the sun). When the ruddy planet arrived at opposition on August 27, 1719, it was only 2½ degrees from perihelion, and on account of its nearness to the earth it shone with such unusual brightness that many people took it for a comet or nova. Maraldi examined Mars with his 34-foot telescope on August 19th. He noticed two obscure bands on the disk making an obtuse angle which exhibited a very conspicuous point; this he found returned to the same place on the disk on September 25th. He concluded that during the interval of 37 days Mars had made 36 rotations. This gave a period of 24 hours, 40 minutes, agreeing with Cassini. Sir William Herschel, in 1777 and 1779, calculated the period as $24^h\ 39^m\ 21^s.67$. Beer and Maedler determined it as $24^h\ 37^m\ 23^s$, practically the same figure given in the *Handbook* of the British Astronomical Association (quoted previously).

We learn from textbooks that the atmosphere of Jupiter is composed largely of methane and ammonia. How can we analyze the gases in an atmosphere so far away? Once again, the answer is that we do it by means of the spectroscope, that instrument which analyzes light, and tells us many things about where the light has been. Radiation from the sun's surface, an incandescent source, contains light of all wave lengths,



Planetary atmospheres can be studied by their spectra; here are infrared spectra of various planets, compared with the sun and some common gases.

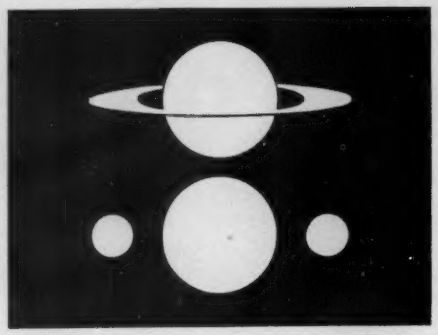
hence it gives a continuous spectrum, a perfect rainbow of colors. As this light comes through the cooler layers of the sun's atmosphere, the gases there extract from the continuous spectrum certain wave lengths of light. As a result of this *absorption,* the spectrum travels to the earth with a number of dark lines crossing it, lines where certain colors would otherwise be. These gaps are characteristic of the elements in the sun's atmosphere, so that we can analyze a part of the sun even though it is nearly a hundred million miles away.

The sun's light travels outward to all the planets: out to the earth, to Mars, Jupiter, and the others. The light by which we see Jupiter is sunlight. If Jupiter were a perfect mirror and the earth had no atmosphere, the spectrum of Jupiter would be identical with that of the sun. But the sunlight penetrates Jupiter's atmosphere before it bounces back to us. In its passage into and out of this dense cloud bank that covers the giant planet, the light picks up more lines in its spectrum, lines that characterize the elements present. Theodore Dunham, Jr., of Mount Wilson Observatory, was able to identify a number of these lines. He reproduced similar ones in light passed twice through a 60-foot pipe containing ammonia and methane, NH_3 and CH_4, respectively. Therefore, it is known that both these gases are present in the Jovian atmosphere.

A question may arise about the light coming through our own atmosphere. Do not the gases here add still more lines to the solar-Jupiter spectrum? Yes, they do, but one way to eliminate the confusion is to make the study of Jupiter's spectrum when Jupiter and the earth (or any other planet in question) are approaching or receding at their maximum relative speed. Then the earth lines (telluric lines) and the planet lines are offset slightly; we have already noted that light from moving sources suffers such a Doppler displacement.

The same effect tells the nature of the rings of Saturn. This curious ring system excited the admiration of Galileo, who was the first to study it with his telescope. He wrote Julian de Medicis, the Tuscan ambassador at the Imperial Court, on November 13, 1610, that Saturn was not a single planet, but triple in nature. The three bodies nearly touched one another, he reported; they were in an east-west line, and the middle one was larger than either of the others. Galileo also modestly remarked that with inferior telescopes the planet appeared oblong, somewhat like an olive!

Galileo soon discovered that changes took place in these appendages. He wrote Castelli, on December 30, 1610, that since July the two bodies had been gradually diminishing, but that they appeared immovable with respect both to



Saturn's rings, as they were oriented in 1610 (at top), and as Galileo's telescope revealed them.

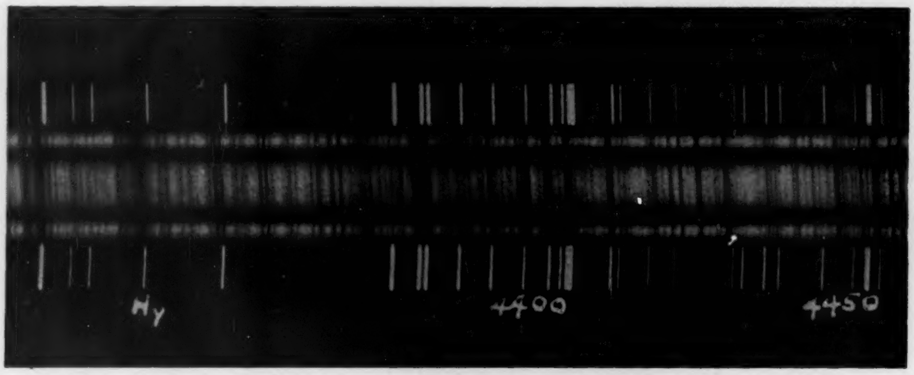
one another and to the central body. This shrinking continued during the next two years and finally the appendages disappeared completely, leaving Saturn as round as Jupiter. Galileo announced this strange disappearance in a letter to Wesler on December 4, 1612. The famous astronomer was greatly concerned over this change. It presented too good an opportunity for his enemies to deny the whole phenomenon that he could not explain. He wrote:

"What is to be said concerning so strange a metamorphosis? Are the two lesser stars consumed after the manner of the solar spots? Have they vanished and suddenly fled? Has Saturn perhaps devoured his own children? Or were the appearances indeed illusion or fraud, with which the glasses have so long deceived me, as well as many others to whom I have shown them? Now perhaps is the time come to revive the well nigh withered hopes of those who, guided by more profound contemplations, have discovered the fallacy of the new observations, and demonstrated the utter impossibility of their existence. I do not know what to say in a case so surprising, so unlooked for, and so novel. The shortness of the time, the unexpected nature of the event, the weakness of my understanding, and the fear of being mistaken, have greatly confounded me."

For the next half century about the only progress in solving the mystery was the discovery of the period of change. The appendages came and went in some 15 years, half the planet's period of revolution around the sun. They were dubbed *ansae,* handles. They first appeared as tiny appendages, but gradually opened up to give a handle-like appearance in each cycle.

The Dutch astronomer, Huygens, revealed the true nature of the rings in 1656 in his pamphlet, *De Saturni Luna Observatorio Nova.* Three years later he published a more extensive book on the subject. His report that "the planet is surrounded by a slender flat ring, everywhere distinct from its surface, and inclined to the ecliptic," is a well-known astronomical statement. He even chanced the prediction that in July or August, 1671, the ring would disappear. Cassini, toward the end of May, noted the disappearance of the ring, confirming the prediction.

In 1675, this latter astronomer discovered in the rings the division that now bears his name. Measures were made of the dimensions, inclination, further divisions, thickness, luminosity, color, and transparency of the system. But the true nature of the rings was still a subject of controversy. Maupertius suggested that they were the tail of a comet Saturn had captured. De Mairain believed that Saturn had shrunk, leaving the ring as the residue of its equatorial regions. Buffon ventured that the planet was liquid and that centrifugal force caused the ring. And there were other speculations.



The spectrum of Saturn, center, its rings, next outside, and comparison spectra of vanadium and iron. Rotation of the planet can be determined from its spectrum, and the independent rotation of particles composing the rings is revealed by the opposite tilt of their spectral lines.

Laplace, however, discussed mathematically the nature of the ring system and decided that it was composed of a multitude of particles, each revolving around the planet. J. E. Keeler, of the Allegheny Observatory, in 1895 confirmed this theory; then V. M. Slipher at the Lowell Observatory photographed the spectrum of the rings. The relative Doppler shifts of the planet and rings establish unmistakably the meteoric nature of Saturn's once mysterious appendage.

Notes on the Velocity of Light

By Duncan Macdonald, *Boston University*

THE ANCIENTS were more familiar with optics than with any other branch of physics, yet this knowledge was limited to the effects of a lens. The nature of light was long a puzzle, one that absorbed the interest of philosophers and scientists alike. Because these early scholars were acquainted with the finite velocity of sound, they speculated on a velocity[1] for light, and their conclusion was generally that light traveled at an infinite rate.

It is easy to see why it was many, many years along the scientific trail before man realized that light was a moving entity whose motion could be measured. No one has ever been conscious of the motion of light as it flows by; in fact, we are more apt to regard light in everyday life as a static phenomenon, either omnipresent or omniabsent. Of course, we know now why it is impossible for us to observe light streaming to the corners of the room as we press the light switch, but let us trace back to the early investigations.

One of the great achievements of the 17th century was the discovery of the finite propagation of light. This came together with the propounding of two mathematical theories as to the nature of light. With either theory, be light a wave or a corpuscle, to consider infinite velocity of propagation would assign properties to either light or its medium of travel that were not compatible with any physical properties found in nature. Hence, there was much interest at that time in experiments which might prove a finite velocity of light.

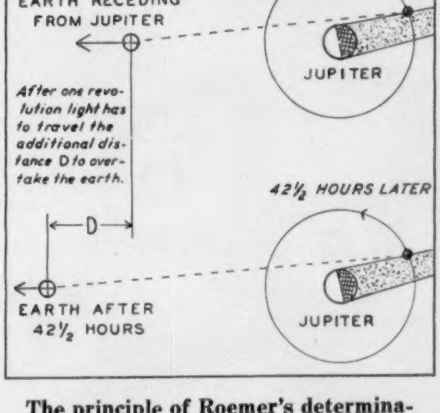
Galileo Galilei (1564-1642), who may, perhaps, be termed the first experimental physicist, made the earliest attempt on record to determine the finite velocity of light. His method was straightforward but far too crude to produce the desired result. He took two observers, each with a lantern and a covering, and placed them a few feet apart. At a signal, observer *A* would uncover his lamp and as soon as observer *B* saw the light he would uncover his lamp. Galileo, near *A*, recorded the time from the starting signal to the instant he saw the light from *B*'s lamp. The experiment was then repeated, this time the men being stationed on hills some distance apart. The additional time taken was to be considered as the time for the light to travel the additional distance. Of course, the times appeared to be the same, and Galileo had failed to prove a finite velocity.

I think it of interest to mention the timing device that Galileo used in many of his experiments, for it gives insight into the ingenuity of the man. A bucket of water with a hole in the bottom plugged with a stopper was the clock. At the word *go*, the stopper was pulled out, and at the end of the interval being timed it was thrust back into its original position. Galileo then assumed that the time consumed would be proportional to the weight of the water that had run out of the bucket.

A few years later, René Descartes (1596-1650) made an attempt to compare measured and computed observations of lunar eclipses. Descartes' only conclusion was that if the velocity of light were finite, then it traveled the distance of the diameter of the earth in considerably less than a second, and he was unable to detect this.

Although Galileo's experiment was unsuccessful, it is coincidental that Galileo's suggestion on a different problem led directly to the first measure of the velocity of light. He had discovered four moons of Jupiter in 1610, and he suggested at that time that a study of their motions be made. This undertaking was begun by Cassini in Paris about 1642.

Ole Roemer (1644-1710) came to Paris from his native Denmark, and while there, observed the eclipses of Jupiter's moons. In addition to his own work, Roemer could fall back on the data gathered by Cassini, data which fixed well the periods of these satellites.



The principle of Roemer's determination of the velocity of light. The first satellite is shown here emerging from eclipse on two successive occasions.

Observation centered on satellite *I*. It has a period of 42½ hours, and as its orbit is nearly in the plane of the earth's orbit, every time it goes around Jupiter it is eclipsed by the planet. Roemer noted that when the earth approached Jupiter the interval between eclipses was less than the 42½ hours, and while the earth was receding, the interval became greater.

What could cause this? I picture Roemer reasoning thus: Jupiter travels much more slowly than the earth and hence I may regard it as stationary as a first approximation. Now if the earth is going away from Jupiter as satellite *I* starts to be eclipsed, by the time the satellite is eclipsed and has fully completed one revolution and is ready to be eclipsed again, the earth is considerably farther away, and the additional time, the time over 42½ hours between eclipses, is the time taken by the light to cover that additional distance. On the other side of the earth's orbit, the distance is diminishing, and so the interval between eclipses should be less.

From his observations, Roemer determined that it would take light about 22 minutes to cross the earth's orbit. (We now believe the value to be a bit greater than 16½ minutes.) But even more uncertain at the time was the determination of the diameter of the earth's orbit. In fact, today, knowing the velocity of light as well as we do, we use Roemer's experiment, not as he used it, but in reverse, to determine the orbital diameter of the earth. Cassini did not accept the new findings as a determination of a finite velocity of light, for Roemer could not check his work using eclipses of any of the other moons. However, Roemer blamed this on irregularities of these other moons not then determined. Roemer estimated the velocity of light to be about 192,000 miles per second, in remarkable agreement with the value we accept today.

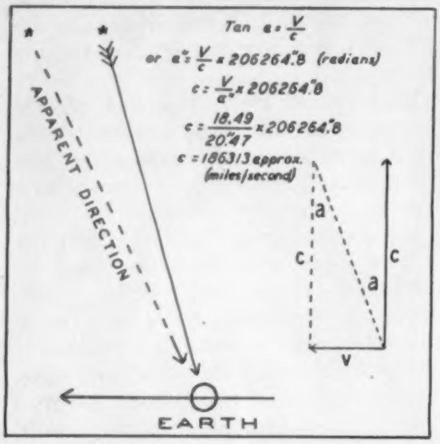
James Bradley (1693-1762) is the next great name we come to in this problem. Prior to 1725, Bradley had been making observations of the fixed stars in an attempt to detect a stellar parallax. He noticed a motion for all stars, a systematic motion that must, he decided, arise from a common cause. The story goes something like this:

"Accompanying a pleasure party in a sail on the Thames one day about September, 1728, he noticed that the wind seemed to shift each time the boat put about and a question put to the boatman brought the (to him) significant reply that changes in direction of the vane at

[1]Although the correct terminology would be **speed** of light, I fall back on historical precedent throughout the article and use the term **velocity.**

the top of the mast were merely due to changes in the boat's course, the wind remaining steady throughout."

With this clue, Bradley correctly assigned this systematic motion of the stars to the finite velocity of light in space. This is the same effect as walking in the rain. If the rain is falling straight down, we observe it as doing such if we stand still, but no matter in which direction we walk, if we are moving, the rain will always appear to be beating down from in front of us. In just this same manner, light changes its apparent



The aberration of starlight displaces the star ahead of the earth. The formula, rough solution, and vector diagram at the right are for maximum aberration, as if the star were at the ecliptic pole.

direction as the earth plows along on its orbit through space, and because of it the stars change their apparent positions, for the light appears to beat down from "in front of" the earth.

Another way of looking at the aberration effect is to consider the star as a hunter shooting arrows of light at the earth. As the earth is a moving target, the arrows that strike it must have been aimed ahead of it.

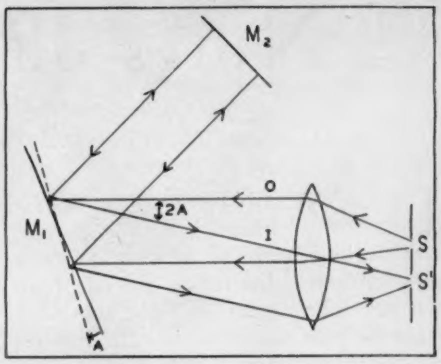
Bradley determined the aberration constant, and taking a value for the earth's orbital speed found the velocity of light. The important point about his observations was that they verified the results of Roemer, which until that time had not been widely accepted as a proof of a finite velocity of light. Bradley stated that based on his observations light would travel from the sun to the earth in eight minutes, 12 seconds.

It was over 100 years later before the first terrestrial method for determining the velocity of light was devised. Armande Hippolyte Louis Fizeau (1819-1896), wealthy French nobleman who found more delight in spending his money on scientific equipment than on the pleasures that occupied his contemporaries, was the man who devised this method.

Fizeau passed a beam of light through one of the gaps in a many-toothed wheel and reflected it back on itself by means of a mirror three or four miles away. When the wheel was at rest or rotating at slow speeds, the reflected beam could be seen, but Fizeau increased the rotation to such a rate that he could not see the reflection. This meant that the flash of light passing through the gap in the wheel was blocked out, as it came back from the mirror, by the next tooth. Fizeau knew the rate of revolution of the wheel, and so calculated the time for the wheel to complete this small fraction of a revolution, which time equaled that required for the light to travel to the distant mirror and back. His result was 3.08×10^{10} cm./sec. for the velocity of light.

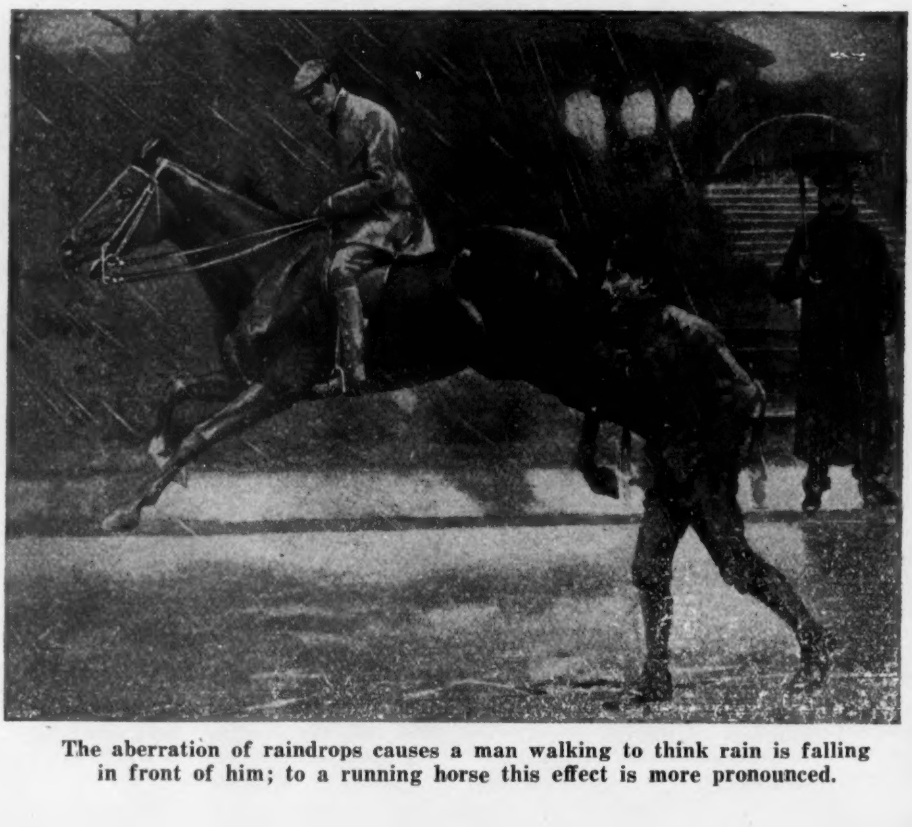
Jean Bernard Léon Foucault (1819-1868) improved the terrestrial technique the year following Fizeau's determination. Foucault's setup, as shown in the diagram, included the image of a slit s focused on a mirror M_1, and reflected from there to a distant mirror M_2. The reflection from M_2 is back to M_1 and out through the slit, along the incident beam. Now if the mirror M_1 is rotating, the reflection from M_2 will not exit through the slit but will appear at s', and the angle formed by the rays to s and s' can be accurately measured. As is easily seen, this angle is twice the angle through which the mirror has turned while the light traveled from M_1 to M_2 and back again. Foucault determined the velocity of light to be 2.98×10^{10} cm./sec. Cornu and Newcomb developed improvements of this method in later years by using multifaced mirrors.

In 1926, Albert Abraham Michelson (1852-1931) made his most famous determination of the velocity of light,

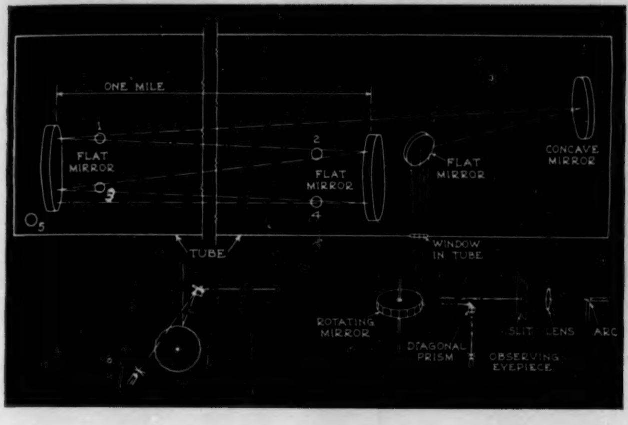


Foucault's method: mirror M_1 rotates through angle A while light travels to M_2 and back. The angle between rays O and I is therefore 2A.

using the essential features of the Foucault method with greatly improved technique, the main improvement being a longer light path. The distance between the mirrors was 35,385.53 meters, about 22 miles, and the probable error of the survey was one part in 6,800,000 (within 1/8 of an inch!). This, by the way, is the most accurate surveying ever done on such a scale. The rotor mirror was originally a glass octagon. The requirement for an observed reflection was that the octagon make 1/8 of a rotation while the light traveled from Mt. Wilson to Mt. San Antonio and back; thus the succeeding face of the mirror is presented to the returning beam at the same angle as the incident beam struck the first face. The speed of rotation necessary to accomplish this was 528 turns per second. The octagon burst on one of the trials, and so new mirrors of 12 and 16 facets were constructed. The speeds for these turned out to be 350



The aberration of raindrops causes a man walking to think rain is falling in front of him; to a running horse this effect is more pronounced.



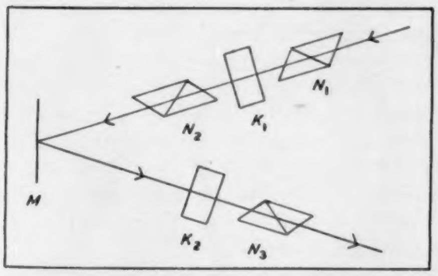
The method of the evacuated tube one mile long is shown here; after passage number 5 the rays retrace their steps to the rotating mirror of 32 faces, thence to the prism and observing eyepiece. At right: Jean Bernard Léon Foucault.

and 264 rotations per second, respectively. The rotation speeds were calibrated by obtaining a stroboscopic effect produced by means of an electrically driven tuning fork, and the fork itself was calibrated by a Bureau of Standards invar pendulum.

Michelson arrived at a figure of (2.99796 ± 0.00004) x 10^{10} cm./sec. for the velocity of light corrected to be the velocity in free space.

To eliminate one uncertainty, that of correcting for vacuum, Michelson, Pease, and Pearson devised an experiment to measure the velocity of light in a mile-long evacuated pipe. By multiple reflections within the pipe, the light path was made 10 miles long. The actual experiment was of the same nature as the original Michelson determination. A 32-faced rotor was used and completed 1/32 of a rotation while the light completed its 10-mile journey. Michelson did not live to see the conclusion of this work that gave a value of (2.99774 ± 0.00002) x 10^{10} cm./sec. (A note to be added is that the error probably overestimates the accuracy of this experiment.)

Fizeau's method was modified and vastly improved by Karolus and Mittelstaedt in 1926 by the use of a Kerr cell



The method of Karolus and Mittelstaedt.

to interrupt the beam of light. The action of the cell of pure nitrobenzene sealed between metal plates is to depolarize light provided there is a high voltage across the plates. Suppose light is polarized by N_1, as shown in the diagram, and then passes through N_2, a second polarizing device. If N_2 polarizes in a plane perpendicular to N_1, no light will emerge, thus if a Kerr cell, K_1, is inserted between N_1 and N_2, a control is obtained. If a voltage is impressed on the Kerr cell, it will neutralize the effect of the first polarizer and the beam will emerge from N_2 as plane-polarized by N_2. If no voltage is impressed, the polarized beam from N_1 will be extinguished by N_2. When conditions are right for a beam to emerge from N_2, it is reflected at a mirror M and is focused on a second Kerr cell, K_2. If a voltage is impressed on this cell, the light is again depolarized and passes through a third polarizing device, N_3, but if there is no voltage across K_2, then N_3 extinguishes the beam. Thus, instead of Fizeau's toothed wheel, a high-frequency voltage was used across K_1 and K_2. Using a light path of about 41.4 meters, Mittelstaedt obtained a result of (2.99778 ± 0.00010) x 10^{10} cm./sec. for the velocity of light in a vacuum. Frequencies as high as 7,205,614 per second were used, while Fizeau could obtain but 50,000 a second with his toothed wheel.

Wilmer C. Anderson, in 1937 at Harvard, made the most recent determination of the velocity of light. Scientific technique and equipment has so improved that the entire apparatus used in this accurate measure was confined to the limits of one room—quite a contrast to the days of Roemer who required the entire orbit of the earth, or even to Michelson and his great outdoor laboratory. Anderson made use of the Kerr cell to modulate the light beam at high frequencies and a photoelectric cell to detect these modulations. He determined the velocity in a vacuum to be (2.99764 ± 0.00015) x 10^{10} cm./sec.

There are indirect means of determining this important constant. Mercier, in 1923, measured the velocity of high-frequency electric waves along wires by producing standing waves in two parallel wires, and from the simple relationship that the velocity of a wave equals its frequency times its wave length, he determined that these waves traveled at (2.99782 ± 0.00030) x 10^{10} cm./sec. in a vacuum.

One of the most interesting relationships in physics is the ratio of the electrostatic and electromagnetic units of electricity. Theoretically, this ratio is the velocity of light. Rosa and Dorsey, in 1906, determined this ratio as (2.99781 ± 0.00010) x·10^{10} cm./sec.

Today, due to the persistence and care and ingenuity of these men and many others, the velocity of light is known with greater accuracy than almost any other physical constant. The accepted value is a weighted mean of the determinations of recent years. This value, as given us by Birge, is (2.99774 ± 0.00004) x 10^{10} cm./sec. Is it any wonder that Galileo failed to detect the velocity of light? For at this rate light would travel around the earth's equator 7½ times in one second. Traveling at the rate of 186,270 miles per second, light is the fastest moving entity we shall ever detect.

LEADING DETERMINATIONS OF THE VELOCITY OF LIGHT

Investigator	*Year*	$\times 10^{10}$ *cm./sec.*			*Method*
Roemer	1675	3.08			Jupiter's satellites
Bradley	1728	2.98			Aberration of light
Fizeau	1849	3.08			Toothed wheel
Foucault	1850	2.98			Rotating mirror
Cornu	1875	2.99990	±	.00200	" "
Michelson	1880	2.99910		.00050	" "
Newcomb	1883	2.99860		.00030	" "
Michelson	1883	2.99853		.00060	" "
Perrotin	1902	2.99880		.00050	Toothed wheel
Rosa and Dorsey	1906	2.99781		.00010	e.s.u./e.m.u.
Mercier	1923	2.99782		.00030	Waves along wires
Michelson	1926	2.99796		.00004	Rotating mirror
Mittelstaedt	1928	2.99778		.00010	Kerr cells
Pease and Pearson	1932	2.99774		.00002	Rotating mirror (vacuum pipe)
Anderson	1937	2.99764		.00015	Kerr cells
Birge	1941	2.99774	±	.00004	Weighted mean

Amateur Astronomers

COPERNICUS AT HARVARD

MEMBERS and guests of the Bond Astronomical Club heard a fine program at the meeting of February 3rd. The spirit of Copernicus, symbolized by an oil painting which was presented to Dr. Harlow Shapley by the Kosciuszko Foundation, dominated the meeting, although the discussion included globular clusters and annular eclipses. The painting is by Maxim Kopf.

The first speaker was Dr. Stephen P. Mizwa, secretary and executive director of the Kosciuszko Foundation. He considered some of the problems now confronting Copernican scholars as to the validity of various traditions surrounding the publication of Copernicus' famous book, *De Revolutionibus,* 400 years ago. There is question as to whether or not Copernicus, on his deathbed, actually saw a printed copy of the book; the original title is in doubt; did Copernicus know about the counterfeit preface which Osiander substituted for the original? Dr. Mizwa then recounted the hundreds of celebrations held in 1943 all over the world in Copernicus' honor.

In presenting the painting of Copernicus to Dr. Shapley, the speaker recalled that in 1922 the Krakow Astronomical Observatory in Poland had received the promise from Harvard of the loan for an indefinite period of an 8-inch telescope; this at a time when the first World War had left the Polish institution without such an instrument. Dr. Mizwa thanked Dr. Shapley for this courtesy and for his services as chairman of the national quadricentennial committee, and requested that the picture "repose in the Harvard College Observatory. There are," he said, "very few places outside of the University of Krakow where Copernicus would feel more at home."

In his ensuing talk on recent revisions in the distances of globular clusters in high galactic latitudes, Dr. Shapley pointed out that the galaxy seems to be surrounded by not only a nearly spherical system of globular clusters but by a "haze" of hundreds of stars distributed in a like manner. The maximum separation of globulars above and below the plane of the galaxy is on the order of 100,000 light-years, or nearly the diameter of the galaxy itself.

Through the courtesy of the New York Amateur Astronomers Association, a short film was shown of the annular eclipse of April, 1940, photographed by Peter A. Leavens from an airplane.

THIS MONTH'S LECTURES

New York City: Dr. Robert I. Wolff, of the College of the City of New York, will speak to the Amateur Astronomers Association on Wednesday, March 1st. His subject will be "Applications of Astronomy to Physics." The public is invited to attend; guest tickets may be obtained from the secretary, George V. Plachy, at the headquarters of the association in the American Museum of Natural History, telephone ENdicott 2-8500, Ext. 478. The meeting is in the museum, at 8:00 p.m. On March 15th, the regular monthly observation meeting will be held, under the guidance of Hazel Boyd, at 8:00 p.m. Assemble in Room 129; the meeting will be held indoors if the weather is not clear.

Philadelphia: The Rittenhouse Astronomical Society will hold a joint meeting with The Franklin Institute in the lecture hall of the institute, on March 1st at 8:15 p.m. Dr. Wallace J. Eckert, director of the Nautical Almanac of the U. S. Naval Observatory, will speak on "The American Air Almanac."

Cincinnati: "Construction of an 8-inch Cassegrainian Telescope, with Simplified Clock Drive," will be described by David B. Hall at the meeting of the Cincinnati Astronomical Association, on Friday, March 10th. Visitors are welcome to this meeting, which will be held at the Cincinnati Observatory at 8:00 p.m. Mr. Hall will exhibit his telescope of the Cassegrain type and a discussion will follow the lecture.

Cleveland: The Warner and Swasey Observatory of the Case School of Applied Science will be open to the public on Thursday and Friday, March 2nd and 3rd, beginning at 8:00 p.m. At 8:30 there will be a lecture on the topic, "Planets Around Other Suns," and observation through the telescope will follow, weather permitting. For reservations, call GArfield 6680.

New Haven: Dr. Victor Goedicke, of Yale University Observatory, will speak on "Galaxies" before the New Haven Amateur Astronomical Society. The meeting will be held at 8:00 p.m., Saturday, March 11th, at the observatory.

Detroit: At 3:00 p.m., March 12th, at Wayne University, the Detroit Astronomical Society will meet to hear one of its members, Daniel Hull, speak on "A Half-Century with the Solar Attachment."

WASHINGTON AMATEURS

At the meeting of the National Capital Amateur Astronomers Association on January 15th, the suggestion was made that members of the armed forces, men and women who are members of astronomical societies elsewhere, be invited to take part in the activities of the society for the length of their stay in Washington, D. C., and environs. This would include honorary membership in the society.

Dorothy F. Harris, secretary, 1621 T Street, N. W., has notified many U.S.O. centers and the like, and she requests that the word be passed on to all Army, Navy, Marine, and Coast Guard personnel.

Members of the N.C.A.A.A. have received a special invitation to attend an evening astronomical conference conducted by Harvard College Observatory at the headquarters of Science Service, Watson Davis, director. This will take place on Saturday, March 4th, and among the speakers will be Dr. Bart J. Bok, of Harvard, and Dr. Walter O. Roberts, of Harvard's solar station at Climax, Colo.

Star Dust is a 4-page mimeographed bulletin distributed to members of the N.C.A.A.A. monthly. From its February issue we find that Dr. Edgar W. Woolard, president of the society, conducts a study group in the history of astronomy; that there is also a group studying celestial navigation. Reviews of the monthly lecture and a Hobby Nook are other features of the pamphlet.

PORT HENRY ASTRONOMY

On the evening of August 4, 1943, at the home of Raymond Moody in Port Henry, N. Y., 14 people of miscellaneous ages and both sexes formed the Port Henry Astronomy Group. Meetings of the group are held at approximately monthly intervals, moving from one member's house to another. The early part of each program consists of an explanation of some phase of astronomy, the discussion being led by Mr. Moody, who was formerly president of the Fulton County (N. Y.) Astronomy Club. This is followed by comment by the members, and, if weather permits, an observation period.

The five meetings held in 1943 have maintained the original membership average, and while the first meeting was ushered in with a terrific rainstorm, the stars have been seen at every meeting since. The moon was observed twice to excellent advantage under different phases, binoculars and opera glasses furnishing optical aid.

Anyone in the vicinity of Port Henry who may be interested in joining this group of amateurs is invited to get in touch with Raymond Moody, 18 Greely St., Port Henry, N. Y.

BEGINNER'S PAGE

By Percy W. Witherell

Man and His Expanding Universe — IV

THE LONG sea journeys of the Polynesians over the vast reaches of the Pacific Ocean and the gradual rising above the horizon of the mountains on the islands of their destinations proved to them that the earth was round. Their "beginning" from an egg or hollow calabash indicates this belief.

The people of the Middle East and of Asia were handicapped by the restrictions of life on the land and the generally prevalent idea that the earth was flat.

As early as 1100 B.C., Chou Kung, a Chinese mathematician, determined the inclination of the ecliptic with great accuracy, but failed dismally in estimating the sun's distance, as he calculated from the hypothesis of a flat earth. The Chinese divided the year into 365¼ days and the circle into 365¼ degrees from the time of the emperor Yao, who ascended the throne in 2317 B.C. Even earlier, they had discovered the Metonic cycle (see below).

In India, very ancient tables to compute the positions of the planets and to predict eclipses have been found.

The Phoenicians were expert navigators, but have left no other evidence of their astronomical knowledge.

Thales, born in Miletus, 640 B.C., taught that the earth was a sphere, and divided it into the five temperature zones; he also taught that the ecliptic crossed the equator obliquely, and that a meridian was perpendicular to the equator. Anaxagoras explained the reason for an eclipse of the moon, was convicted of impiety; he and his family were sentenced to death, but this was commuted to banishment.

Pythagoras taught publicly that the earth was the center of the universe, but privately he told his pupils that the earth revolved around the sun. Heraclides taught that the apparent motion of the stars was due to the rotation of the earth.

Meton started the cycle that bears his name, July 16, 433 B.C. It consisted of 125 *full* months of 30 days and 110 *deficient* months of 29 days, a total of 6,940 days for 235 lunations and 19 solar years. This was engraved as the "golden number" on tables of brass and is still in ecclesiastical use. About 370 B.C., Eudoxus of Cnidus introduced the year of 365¼ days to the Greeks and tried to give a mechanical explanation of motions of the planets by the use of many spheres. Plato brought geometry to the aid of astronomy and proposed to represent the orbits of the celestial bodies by circular and regular motions. Calippus corrected an error of one quarter of a day in the Metonic cycle by using four cycles or 940 lunations less one day. Timarchus determined the relative positions of the stars in the zodiac. Previously, only the times of their risings and settings had been recorded.

After the Macedonians became the rulers of Egypt, and Alexandria gradually superseded Athens as the center of culture, great libraries were established by the sovereigns. Ptolemy Euergetes appointed Eratosthenes, who was born in Cyrene but studied in Alexandria and Athens, to be royal librarian. Eratosthenes laid the foundations of mathematical geography. Learning that at the time of the summer solstice the sun cast no shadow from vertical posts or walls at Syene, located about 500 miles south of Alexandria, he thought of a method to determine the size of the earth. At noon of the summer solstice, he measured the zenith angle of the sun at Alexandria by stretching a string from the top of a vertical peg to the extremity of its shadow and measuring the angle at the upper end. On the assumption that the sun was very far away, so its rays were parallel when they struck the earth, he showed that the angle of the shadow was the same as the angle at the center of the earth of the arc of its surface between Syene and Alexandria. This arc of 500 miles proved to be close to 1/50 of a circle, which gave 25,000 miles as the circumference of the earth over the poles. A later observation by Eratosthenes, in which he used a gnomon in a special sundial, increased this figure a few hundred miles. Eratosthenes thus demonstrated the value of direct observations, rechecked by improved methods, and of the application of mathematics.

A less successful attempt to apply the principles of geometry to a measurement of the relative distances of the moon and the sun had been made by Aristarchus of Samos about 70 years earlier. He reasoned that at first quarter (half moon) the angle at the moon between the directions of the sun and the earth is 90 degrees, and that if he measured the angle between the directions of the sun and the moon at the earth he could solve the right triangle. Unfortunately, he had no idea of the real distance of the moon and no accurate means of measuring the required angle, so that his result was only 1/20 of the actual value.

Aristarchus will long be remembered as the first to suggest publicly the idea that the earth was not the center of the universe but was a planet, and that all the planets revolved around the sun. He was accused of impiety, but did not suffer physically for his revolutionary idea. (This was in 270 B.C. and for 1,800 years, until the days of Copernicus, the truth remained hidden.)

Euclid helped the future astronomer by his book on the sphere. Archimedes prepared a planetarium which showed the motions of the sun, moon, planets, and starry sphere.

PITTSBURGH TELESCOPE-MAKING CLASS

A course of lectures on "Amateur Telescope Making," sponsored by the Buhl Planetarium and Institute of Popular Science and the Amateur Astronomers Association, was scheduled to begin in Pittsburgh on February 25th. The course consists of four lectures given by members of the amateur group, on the fourth Friday evening of each month, starting in February. The complete schedule includes:

Feb. 25, "Fundamental Optical Principles of the Telescope," by C. A. Atwell and H. M. Priest.

Mar. 24, "Mirror Making," by Leo N. Schoenig.

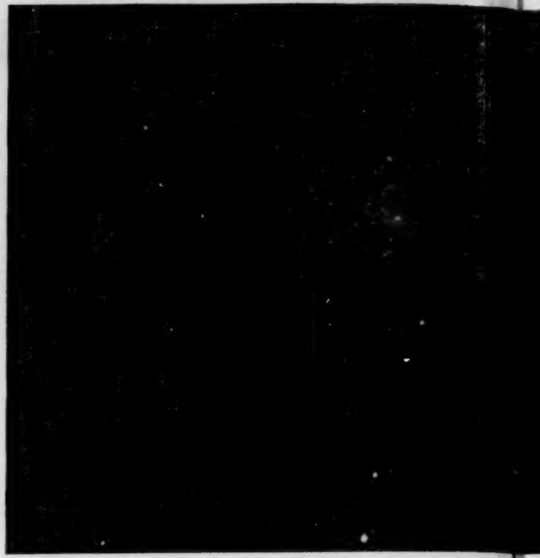
Apr. 28, "Mounting the Telescope," by Norman J. Schell.

May 26, "Pleasures of Observing with a Telescope," by W. A. MacCalla and Leo J. Scanlon.

The lectures will not be of a technical nature, and are intended to have popular appeal. All members of the Pittsburgh group are urged to attend, and to invite their friends who may be interested. There will be no charge for the course; the only cost to non-members is the 10-cent admission at the door of the planetarium building.

BEAVER AMATEURS ORGANIZE

William A. Lintz, of 440 Navigation St., Beaver, Pa., writes that the Beaver County Amateur Astronomers Association has been formed, with 13 members at the end of January and more members expected to join in the future. Three successful meetings have been held. The officers of the society are Paul L. McConnell, president; Keith Shields, vice-president; and Mr. Lintz, secretary.



Two unusual galaxies in Sculptor. (Above) NGC
with practically no central condensation. Rig
classed as spiral but possibly a double ir

THE FAR S

And I say to any man or woman,

FIRST among the most marvelous things that human eyes can see are the galaxies. Mostly emptiness and darkness, they consist also of billions of stars and dust and gaseous stuff from which stars may be evolved. They are too vast to be comprehended, but they can be glimpsed in miniature across quintillions of miles of space.

From locations within the United States at least 30 of these vast systems can be seen with a 3-inch telescope. Seventeen especially are easy. In amateur reflectors they appear to be as insubstantial as ghosts, tiny, indistinctly outlined clouds, "only slightly more brilliant than the dark background of the sky," as M. de Maupertius explained.

Galaxies are the building blocks of infinity. A poet might call them the steppingstones of God. Changing the figure, we may picture them as brain cells of the Cosmic Mind. But such descriptions must not be taken literally; they are merely poetic fancies.

All the great religions were founded before these vast units were discovered, and all the major philosophies were written before the nature of these wonders was determined beyond a reasonable doubt. Yet these far-flung universes must be included whenever men seek to unlock the mysteries of human life and destiny. Modern astronomical discoveries, according to Shapley, are "the stuff that philosophic dreams are made of . . . feeders of the inherent religious hunger."

Why were galaxies formed? One hundred million are within the range of the 100-inch telescope, Hubble tells us —so many that "compilation of general catalogues," he says, "is neither practical nor important." Why so many?

In the story of human progress 1924 is an outstanding date, for in that year Hubble proved that the galaxies were independent universes—too far away to be members of our own Milky Way system. This he accomplished by finding Cepheid variable stars in M31 and M33, two frequently pictured spirals. Calculation showed that the distance was about 700,000 light-years, though M31 is near and bright enough to be seen, without optical aid, as a blurry spot.

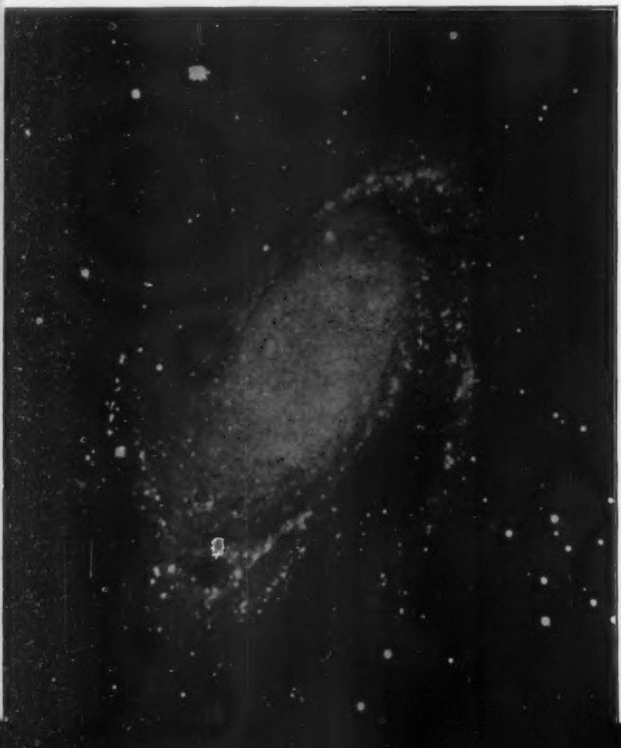
When, in the words of Walt Whitman, we open a "scuttle" to "see the far-sprinkled systems," our amateur telescopes show us tiny circles, ovals, and bars or splinters of light, very faint and vastly far away. And that is all.

Aided by photography, professionals distinguish three main types—elliptical (E), spiral (S), and irregular (I). Ellipticals vary from spheres to spindles, and spirals appear as normal and barred. Irregulars, which make up only a small percentage, fail to follow any standard pattern.

Galaxies are found alone, in pairs or small clusters, and in vast aggregations. Twins are especially interesting. Three examples of these can be seen with large amateur telescopes—NGC 4490, a spiral, and its elliptical companion, in Canes Venatici; M60, elliptical, and NGC 4647, spiral, in Virgo; and NGC 4567-68, an interlocking double in Virgo, pictured on the front cover this month.

Our own Milky Way system is a member of the local group of about 15 objects. These extend through space for a million light-years, with our galaxy near one end of the formation. Our position in the local group helps to explain why relatively close specimens like M82 (Ursa Major), NGC 4631 (Canes Venatici), and M51 (Canes Venatici), all of which are strongly recommended for amateur observation, are not a part of our group, while individuals that common telescopes cannot see are included. Among members are the Magellanic Clouds, closely allied with our Milky Way system; the triple universe (M31, M32, NGC 205) in Andromeda; NGC 6822, which might

The spiral nebula Messier 81 in Ursa Major is on the order of a million light-years distant. It appears close to M82 in the sky.



LIST A. GALAXIES EVERYONE SHOULD KNOW

NGC	R.A. h m	Dec ° '	Norton Atlas	Const.	Size, '	Ptg. Mag.	Type	Notes (with appearance in amateur telescopes)
55	0 12.5	-39 30	2315h	Scl	25x3	7.8	S	Large, fluffy
221	0 40.0	+40 36	M32	And	2.6x2.1	9.5	E2	Small, oval
224	0 40.0	+41 00	M31	And	160x40	5 ±	Sb	Great Spiral. 700,000 l-y.
253	0 45.1	-25 34	1^{5}	Scl	22x6	7.0	Sc	Large, fluffy
598	1 31.1	+30 24	M33	Tri	60x40	7.8	Sc	Large, very dim, 700,000 l-y.
3031	9 51.5	+69 18	M81	UMa	16x10	8.9	Sb	Oval, 1,600,000 l-y.
3034	9 51.9	+69 56	M82	UMa	7x1.5	9.4	I	Edge-on, handsome
3115	10 2.8	- 7 28	163'	Sex	4x1	9.8	E7	Lenticular, small
3627	11 17.6	+13 17	M66	Leo	8x2.5	9.9	Sb	Oval, 4,300,000 l-y.
4594	12 37.3	-11 21	43'	Vir	7x1.5	8.1	Sa	Sombrero. Brightest galaxy, 7,200,000 l-y.
4631	12 39.8	+32 49	42^{5}	CVn	12x1.2	9.6	Sc	Edge-on, choice specimen
4736	12 48.6	+41 23	M94	CVn	5x3.5	9.0	Sb	Roundish, 3,000,000 l-y.
4826	12 54.3	+21 47	M64	Com	8x4	8.0	Sb	Oval, dim, 1,300,000 l-y.
5128	13 22.4	-42 45	482^{6}	Cen	10x8	7.2	I	
5236	13 34.3	-29 37	M83	Hya	10x8	8.0	Sc	Large, dim, 2,900,000 l-y.
5457	14 1.4	+54 35	M101	UMa	22x22	9.0	Sc	Big, very dim
7793	23 55.3	-32 51	Near 5	Scl	6x4	9.7	S	Vague oval

Data after "Survey of External Galaxies," by Shapley and Ames, Annals of Harvard College Observatory, Vol. 88, No. 2, 1932.

Sa, early spiral; Sc, late spiral; Sb, intermediate type. SB, barred spiral; E, elliptical; I, irregular.

ove) NGC 7793, a spiral
ion. (Right) NGC 55,
ouble r irregular.

R SPRINKLED SYSTEMS

BY L. S. COPELAND

r womn, Let your soul stand cool and composed before a million universes.

—Walt Whitman, "Song of Myself"

be called the Bear Starcloud because in photographs it resembles a dancing grizzly; and M33, the wide-armed spiral in Triangulum.

With unaided vision we can see, in addition to the Milky Way, which is the concentrated part of our own galaxy, the two Magellanic Clouds and M31. Also, under the best conditions, M33 has been glimpsed by a few keen-eyed persons.

Herewith are the positions of the best galaxies for amateur observation. All objects in List A can be found with comparative ease, and most, if not all, of List B can be sighted through a 3-inch telescope.

As we observe galaxies by means of light that left them ages ago, they "are as truly fossils as are the eggs of dinosaurs," as a *Leaflet* of the Astronomical Society of the Pacific picturesquely explains. For example, the photograph shown on the back cover of *Sky and Telescope,* June, 1943, presents the Corona Borealis cluster, 135 million light-years away. When the light from these 400 objects started earthward, dinosaurs were walking this planet, back in Jurassic times. Frontier galaxies can be listed in the Cambrian period. The cluster nearest to us, the Coma-Virgo, seven million light-years distant, is observed as it was in Pliocene days. And most of the galaxies that amateurs see are Pleistocene "fossils."

Though the owner of a large amateur telescope can sight in a single night at least 30 of the 300 Coma-Virgo systems, they are too close together for easy identification. The amateur should remember that the best galactic nook in which to look with a common telescope is Canes Venatici, which shines near the top of the sky these spring nights.

In the celestial north polar country, where universes are more numerous than stars, faintly gleam the Hunting Dogs. The starry greyhounds, as we affectionately may call them, were ignored by the ancients, but within the last three centuries they have won recognition and fame. They have brought in such choice game for the astronomical feast—so many handsome cosmic systems—that today they are listed among the leading denizens of the heavens. Aptly, we can apply to them the words of the Gospel poem and of Longfellow's *King Robert of Sicily,* "He has exalted them of low degree."

The circular map of Peter Apian, 1536, presents the Hunting Dogs as helpers of Bootes, who holds high their two long leashes. Besides the greyhounds, there is a third dog resembling a spaniel. Tycho Brahe's atlas of 1602 pictures this constellation as a river, and Augustine Royer, in 1679, called it the Jordan. But this change was rejected by Johann Hevelius of Danzig, who turned the thinly starred group back into two greyhounds, Asterion and Chara.

Fame came to Canes Venatici because of its hidden treasures. Twelve galaxies can be seen with a large amateur telescope, and at least eight can be glimpsed through a good 3-inch aperture in clear air on moonless nights.

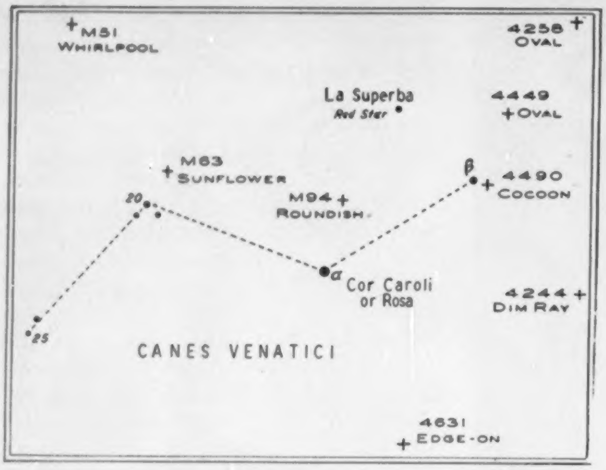
If you wish to go galactic gunning with the Hunting Dogs, try M51, the Whirlpool, a double, just under the

LIST B. OTHER GALAXIES FOR COMMON TELESCOPES

NGC	R.A. h m	Dec ° '	Norton Atlas	Const.	Size,'	Ptg. Mag.	Type	Notes (with appearance in amateur telescopes)
247	0 44.6	−21 01	Near β	Cet	18x5	10.7	S	Large, dim
1291	3 15.5	−41 17	487^a	Eri	5x2	10.2	E	
2403	7 32.0	+65 43	44^5	Cam	16x10	10.2	Sc	
2683	8 49.6	+33 38	200'	Lyn	10x1	10.8	Sc	
2841	9 18.6	+51 12	205'	UMa	6x1.6	10.5	Sb	Large, dim, oval
2903	9 29.3	+21 44	56'	Leo	11x5	10.3	Sc	Fuzzy, oval
3368	10 44.2	+12 05	M96	Leo	7x4	10.4	Sa	Oval, dim
3521	11 3.2	+ 0 14	13'	Leo	4.5x...	10.3	Sc	
3623	11 16.3	+13 23	M65	Leo	8x2	10.5	Sb	Oval
4244	12 15.0	+38 05	Near 166'	CVn	13x0.9	11.0	Sb	Dim ray
4254	12 16.3	+14 42	M99	Com	4.5x4.5	10.5	Sc	Roundish, bright center
4258	12 16.5	+47 35	43^5	CVn	20x6	10.2	Sb	Oval, bright center
4303	12 19.4	+ 4 45	M61	Vir	6x6	10.4	SBc	Large, round, dim
4382	12 22.8	+18 28	M85	Com	4x2.5	10.5	E	
4449	12 25.8	+44 22	213	CVn	4.5x2.5	10.3	I	Oval
4472	12 27.3	+ 8 16	M49	Vir	4.5x4	10.1	E	Dim, small, roundish
4490	12 28.3	+41 55	198'	CVn	4x1.8	10.5	Sc	Cocoon. Between round galaxy and a star
4565	12 33.9	+26 16	24^5	Com	15x1.1	10.7	Sb	Famous edge-on
5055	13 13.5	+42 17	M63	CVn	8x3	10.5	Sb	Sunflower. Elongated, bright center
5194	13 27.8	+47 27	M51	CVn	12x6	10.1	Sc	Whirlpool. Suggestions of arms

Data after "Survey of External Galaxies," by Shapley and Ames, Annals of Harvard College Observatory, Vol. 88, No. 2, 1932.

Sa, early spiral; Sc, late spiral; Sb, intermediate type. SB, barred spiral; E, elliptical; I, irregular.



(Left) The constellation of the Hunting Dogs, showing its eight most conspicuous galaxies; also Cor Caroli and La Superba, a blood-red 5th-magnitude sun. (Right) The spiral Messier 83, in Hydra, as photographed at Harvard's southern station.

handle of the Big Dipper; M63, resembling a sunflower (in photographs), near star 20; M94, an oval irregular, north of Alpha (now Cor Caroli, once known as Rosa); NGC 4631, irregular edge-on, south of Alpha; and NGC 4490, cocoon-shaped spiral beside a wee round galaxy, both west of Beta.

ASTRONOMICAL ANECDOTES

SUNSPOTS AND DINNERS AND SOLAR FLARES

SOMETIMES the simplest solution to the problem is so obvious that it gets overlooked; too often we prefer to keep on doing things the hard way. That seems to have been true with the short-wave communications which were so often upset when a solar flare occurred. Short-wave radio was thrown into confusion, while the long-wave and broadcast regions of the radio spectrum were undisturbed. Now it has occurred to our Signal Corps experts that a good way to avoid interference with short-wave messages is to use long-wave transmission! Of course, the power requirement is greater, and the range is less, necessitating a chain of stations to get a message across, but interruptions should no longer occur.

While we are thinking of things solar, I am reminded that I have a copy of the *Royal Astronomical Society Club Records,* 1820-1903, presented by Prof. H. H. Turner, the compiler, to Prof. W. J. Hussey, on the occasion of his visit to Oxford in September, 1905. The R. A. S. Club really preceded the formation of the society itself, for it was at a dinner of a few astronomical friends at the Freemason's Tavern that the idea of the society originated, on January 12, 1820. Then the club was perpetuated as a group never to exceed 20 in number of members, all to be fellows of the society, to meet at dinner before the regular sessions of the society. The number was later increased, and certain provisions were made for honorary members and guests, but the club remained as a little group inside the organization of the society.

But now, to get back to the sun, I find on pages xxix-xxxiii of the *Records,* an interesting tabulation and discussion of the cost of the dinner, per head. I quote the paragraph of summary, written by Turner:

INFLUENCE OF SUNSPOTS

The Treasurer's accounts at the anniversary meeting, which include various statistics of the number of guests, the ratio of guests to members, and so forth, are usually stated with gravity and received with levity. It has several times been suggested that the figures should be analysed to see whether the cost of dinner was subject to the influence of sunspots: and since it is desirable to avoid prejudice in such matters, the analysis has been undertaken. There is an obvious secular change in the above figures, though the rate is not very accurately manifested. Taking it as one penny per year and reducing all the figures to the date of foundation of the Club as epoch, we get from the average of the seven periods of eleven years, from 1820-96, the following mean values for the cost of a dinner in pence, omitting a constant of 175 pence to render the change more obvious.

Year	1	2	3	4	5	6	7	8	9	10	11
Cost	16	11	18	9	7	1	13	14	9	18	16
Smoothed	15	15	13	11	6	7	9	12	14	14	17
Again	16	14	13	10	8	7	9	12	13	15	15

There is an obvious minimum in the year of the cycle numbered 6. The first year being 1820 + 11n, the minimum falls about 1825 + 11n; which gives a minimum, for instance, when n = 5 at date 1880, a little later than the sunspot minimum. This seems to show that the influence of the sunspots on the price of food is not felt immediately, doubtless owing to the fact that the construction of the food requires time.

Many do not know that there is only one instance of a solar flare or eruption on the sun's disk observed directly at the telescope, without using some form of the spectroscope. This was on September 1, 1859, when Carrington and Hodgson saw the eruption between 11:18 and 11:25 in the morning. At the Kew magnetic observatory there was found what is called a "crochet" in the magnetic tracings for that day, beginning at 11:15, with its greatest displacement at 11:25; the Greenwich traces for the same day give the beginning at 11:20 and the maximum at 11:28. The differences are in the time recording and in the measurement, and are not real. The magnetic declination increased about 15′ westward; the horizontal force was —130 gammas, the greatest crochet ever observed for a solar flare. Then, more than 17 hours after the flare and the crochet, a great magnetic storm occurred; there had been an earlier one on August 28th, perhaps produced by an unobserved earlier flare. At the times of both storms, there were observed magnificent displays of aurorae, as far south as Cuba.

I believe there is something new here, for most of us. We usually hear that the magnetic storm follows the flare by about a day; that seems still to be true, but additionally now we must expect a smaller magnetic disturbance at the time of arrival of the radiation from the flare. The situation is summed up by H. W. Newton in the British Astronomical Association *Journal* for November, 1943, from which these details have been extracted:

The crochet perturbation is evidence of a burst of ultraviolet radiation eight minutes before on the Sun, and, like visible radiation, its effect is limited to the Earth's day hemisphere. It is generally accepted, on the other hand, that a magnetic storm is due to the impact on the Earth's upper atmosphere of a stream of solar particles (affecting the night as well as the day hemisphere) whose effective time of travel from Sun to Earth is of the order of one day.

R. K. M.

NEWS NOTES

BY DORRIT HOFFLEIT

TITAN'S ATMOSPHERE

Titan, the principal satellite of Saturn, was discovered by the Dutch astronomer and physicist, Huygens, with his long tubeless telescope in 1655. It was the fifth satellite, aside from our own moon, to be discovered in the universe. Only two other moons, Callisto and Ganymede, belonging to Jupiter, are larger than Titan, which has a diameter of about 2,600 miles. That Titan has an atmosphere has been suspected for a long time, but heretofore nothing has been known about its composition. (See Jeans, *Dynamical Theory of Gases,* 1925.)

Late in January, Dr. Gerard P. Kuiper, of Yerkes Observatory, and also a Dutchman, reported from the McDonald Observatory in Texas that he had obtained spectra of Titan in red and infrared light. These spectra reveal an atmosphere rich in hydrogen. It is much like the atmosphere of Saturn itself, containing methane (marsh gas) and possibly ammonia. The molecule, methane, is made up of one atom of carbon and four of hydrogen; ammonia is one of nitrogen and three of hydrogen. Life, as we know it, is as much out of the question on Titan as on Saturn.

THE FAINTEST STAR, TO DATE

Progress in observational astronomy embraces ever fainter and fainter objects. Most of those of prime interest recently have been literally invisible to their discoverers (notably Strand's companion of 61 Cygni), revealing themselves through the gravitational perturbations they exert on visible stars.

Dr. G. Van Biesbroeck has, however, found a star much fainter than any known to date. Moreover, he has actually seen it, or rather, its photographic image has been obtained by him. And it *is* a star, there being little room for speculation, as there is in the case of Strand's discovery, as to whether it is star or planet.

On intercomparing plates taken with the 82-inch reflector at McDonald Observatory, Dr. Van Biesbroeck discovered that the star known as BD + 4° 4048, magnitude 9.5 visual, has an 18th (red) magnitude companion 74 seconds away, corresponding to a separation of 440 astronomical units. Whereas such a faint star would usually have no measurable apparent motion across the sky because of its probable great distance, this one is found to have the same proper motion as the bright star. The distance of this star is known to be somewhat less than 20 light-years, and its proper motion has been, therefore, well determined. At this relatively small distance, the companion has an absolute magnitude of +19, as compared with about +5 for our own sun. About a million stars like the newly discovered one are needed to equal the sun in combined brilliance; and our sun itself is a dwarf!

Considering the great distance (440 earth-sun units) of the faint star from BD + 4° 4048, astronomers believe that the new object shines by its own and not by reflected light. Hence the question of whether or not it is a planet does not arise. Data are not yet available to determine its mass. In the case of 61 Cygni's invisible companion, it was the mass but not the luminosity that could be determined. As more becomes known about these classes of objects, and more stars like Van Biesbroeck's are discovered, the problem of the real boundary, if any, between large planets and faint stars will become clarified.

The intrinsically faintest star hitherto known is called Wolf 359. It is three magnitudes (absolute) brighter than Van Biesbroeck's star or about 15 times brighter.

NOVA PICTORIS

Dr. J. S. Paraskevopoulos, of Harvard's station at Bloemfontein, South Africa, reported late in January that with the Rockefeller 60-inch reflector he has photographed Nova Pictoris 1925 with exposures of 30, 60, and 120 minutes, and has found the image distinctly elongated in position angle approximately 70°. He finds no trace of the diffuse nebulosity which normally surrounds many of the novae years after their outburst.

Nova Pictoris reached a magnitude of 1.2 in 1925. Evolutionary phenomena similar to those observed for Nova Herculis 1934 and Nova Persei 1901 have apparently taken place within Nova Pictoris. These explosive phenomena may be linked with the evolution of planetary nebulae, but there is as yet no good evidence that they are connected with the evolution of planetary systems.

A FIND

H. H. Nininger, famous collector of and authority on meteorites, was recently scouting for prospective oil structure in the northern part of Cowley County, Kansas. He had gone to a farmhouse for a drink of water and as he was working the pump his practiced eye spied a rusty-looking stone under some plum bushes. Sure enough, a new meteorite!

"It is not often," says Dr. Nininger, "that the *student* of meteorites has the good fortune actually to come upon a meteorite, without some other person's leading him to it." Dr. Nininger has found innumerable meteorites when he was actually in search of them in favorable regions—both with and without the help of his ingenious "magnetic rake." The new 4-pound aerolite he found (reported in *Popular Astronomy*) is pure luck. No other meteorite has yet been found within 50 miles of this one.

VOLCANOES ON JUPITER?

In a number of the *Astronomische Nachrichten* (a German publication) for 1942, E. Schoenberg discusses a theory on the dynamics of the atmosphere of Jupiter. He finds that the banded appearance of the planet could be accounted for if Jupiter had a solid surface with certain zones in which hot cracks or volcanoes were common. The dark belts would arise through condensations resulting from the eruptions.

LIFETIMES OF CLUSTERS OF GALAXIES

In certain regions of the sky, exterior galaxies are found to occur in huge clusters which seem to be physically related. The Coma and the Virgo clusters are the most famous of these. Merle Tuberg, working under the direction of Dr. S. Chandrasekhar at Yerkes Observatory and applying his theory of dynamical friction, has investigated the chances that members of these clusters will escape and that the clusters will eventually disintegrate. The half-lives computed for the clusters imply an upper limit to the age of the universe (as we conceive the universe) of from 100 billion to a trillion years (10^{11} to 10^{12} years).

COMET PREDICTIONS

The *Handbook* of the British Astronomical Association for 1944 (just received) gives predictions for four periodic comets which may be looked for this year. Three of the ephemerides are simply continuations of ones given last year for late 1943. Of these, Comet Comas-Sola 1927III was already found by Miss Oterma in Finland in October. Two others have been searched for by Van Biesbroeck and others in this country without success, namely Comet Schaumasse and Comet Daniel 1909IV. The latter, however, according to *Nature,* December 25, 1943, had been found on November 30th by G. F. Kellaway, of West Coker, England.

The fourth expected visitor is the famous Comet Encke, which will pass perihelion early in August and nearest to the earth late that same month. Conditions are unfavorable for it to reach naked-eye brilliance, which it attains on occasion. It was first seen in 1786, and has been observed every 3 1/3 years since Encke proved it periodic in 1818.

BOOKS AND THE SKY

A TREASURY OF SCIENCE

Edited with an Introduction by Harlow Shapley, with Samuel Rapport and Helen Wright. Harper and Brothers, New York and London, 1943. 716 pages. $3.95.

THIS is a wonderful book. It is truly a "treasury" of great value, for Dr. Shapley and his colleagues have chosen the indisputably beautiful and significant gems of scientific literature in the last few centuries. Most of it, however, is modern, in spirit if not always in date. The delighted reader will range in these essays and articles from the clear and lucid statements of Copernicus and Galileo, world-shaking in their revolutionary significance, to the charming and heart-warming "Flowering Earth" of Donald Culross Peattie and the entertaining and moving "Ancestors" written by Gustav Eckstein.

Here you will find Einstein, Huxley, Eve Curie, Darwin; Victor Heiser telling the fascinating story of leprosy in the Philippines and its heroic conquest; George W. Gray, that prince of popular science writers, interpreting with clarity and brilliance some of the more difficult phases of modern scientific investigation; Stefansson, Beebe, de Kruif, James Harvey Robinson, and the psychologist, Brill. They are all here, and many more, interpreting, integrating, bringing together the loose strands of the vast fabric of science.

Dr. Shapley himself has written a delightful introduction to this anthology, and he has called it "On Sharing in the Conquests of Science." Perhaps there is no better way of giving the tone of the book than by a brief quotation from this introduction:

"Perhaps the greatest satisfaction in reading of scientific exploits and participating, with active imagination, in the dull chores, the brave syntheses, the hard-won triumphs of scientific work, lies in the realization that ours is not an unrepeatable experience. Tomorrow night we can again go out among the distant stars. Again we can drop cautiously below the ocean surface to observe the unbelievable forms that inhabit those salty regions of high pressure and dim illumination. Again we can assemble the myriad molecules into new combinations, weave them into magic carpets that take us into strange lands of beneficent drugs and of new fabrics and utensils destined to enrich the process of everyday living. Again we can be biologist, geographer, astronomer, engineer, or help the philosopher evaluate the nature and meaning of natural laws."

And so, an invitation to the charms of science by a master scientist and teacher. For among the great minds of our day, Harlow Shapley's stands out—technical scientist and explorer of the unknown quantity of space, teacher and inspirer, writer and lecturer who can talk so that the layman listens and understands.

A Treasury of Science is divided into five main sections, the first of which is Dr. Shapley's introduction. The second division is labeled "Science and the Scientist," and here we find that delightful story by Dallas Lore Sharp, "Turtle Eggs for Agassiz." If you haven't read that one, it alone will be worth the price of the book. In this section, too, The Aims and Methods of Science are touched upon by such disparate authorities as Roger Bacon out of the 13th century, and Einstein, Eddington, Pavlov, and Fosdick out of our own.

The third section, "The Physical World," is divided up again into The Heavens, The Earth, and Matter, Energy, Physical Law. Here you can travel from the serious side of the physical world under such sober-minded guides as Eddington, Jeans, Kaempffert, and Benjamin Franklin, to such light-hearted bits as C. C. Furnas' "On Atoms—Slightly Sarcastic."

In the fourth part of the book, "The World of Life," the reader will learn much, and painlessly, not only of The Spectacle of Life, but of that well-known and constantly pursued Riddle of Life.

"The World of Man," Part Five, progresses from From Ape to Civilization through The Human Machine, The Conquest of Disease, and Man's Mind, to the last phase of all, Man's Future. Fittingly enough, this book of theories and facts ends with an essay by Haldane, "The Last Judgment."

A Treasury of Science is a book which the intelligent layman, even mildly interested in the world in which he lives, cannot do without. It is wonderfully good reading, it is clear, it is entertaining. There is a wide variety of styles and subject matter to choose from. But lest, in reading this, the scientist should con-

NEW BOOKS RECEIVED

BELOVED SCIENTIST, *David O. Woodbury*, 1944, *Whittlesey House*. 358 pages. $3.50.

Biography of Elihu Thomson, "a guiding spirit of the electrical age." His interest in astronomy and telescope making makes up part of the book.

UNIVERSAL STAR MAP, *Arthur E. Merrill*, 1944, *The author*, 1567 Kingston Ave., Schenectady 8, N. Y. Unpaged, with maps. Universal map only, 50 cents; circumpolar map only, 25 cents; both maps, with notes and planet finder charts for 1944, $1.00.

Blueprint charts, one of the "orange-peel" style covering the entire sky, one north circumpolar. The notes include observing data month by month, pronunciations, some astronomical facts and mythology, and planet charts for 1944.

THE CONSTELLATIONS as seen from South Africa on any night in the year, *Arthur W. Long*, 1922, *Juta and Co., Ltd.*, Cape Town and Johannesburg. 33 pages. 4s 6d.

Twelve charts of Southern Hemisphere skies, suitable for use anywhere below the equator.

THE CONTRIBUTION OF HOLLAND TO THE SCIENCES, *Barnouw* and *Landheer*, 1943, *Querido*. 373 pages. $3.50.

A collection of articles by Dutch authors now in the United States, including 13 chapters on various phases of the humanities and social sciences, and seven contributions on the exact sciences and architecture.

clude that this is a book simply for the uninitiated, let me close by quoting again:

"A contribution toward the integration of science is . . . one goal of this volume. We hope that it may be of particular value to the scientific worker himself. No one works effectively in more than one or two of the special fields. The average specialist is just as uninformed about science remote from his specialty as is the general reader. A familiarity with other disciplines should not only be good entertainment, but instructive as to techniques and attitudes. But of most importance, the scientific specialist, while reading abroad, is informing himself on the inter-fields of science, or at least on the possibility and merit of inter-field study. If this volume can assist in however small a way in the integration that seems essential to man's intelligent control of his own fabrications, it will have attained the desired end."

MARIAN LOCKWOOD
Hayden Planetarium

WEATHER AROUND THE WORLD

Ivan Ray Tannehill. Princeton University Press, Princeton, N. J., 1943. 200 pages. $2.50.

IF ONE were due to sail from Norfolk, Va., for Perth, Australia, via Newfoundland, England, Portugal, South Africa, Ceylon, this handy little volume would tell what kind of weather to expect, according to the month, at every stage of the journey. General information on the elements — prevailing winds, size of waves, clouds, storms, ocean currents, temperatures, humidity, rain, snow, fog — occupies the first seven chapters. There is not much theory and no mathematics. The elements are considered chiefly with respect to climate and the comfort of the traveler; but the pages are filled with enlivening facts of broader interest. Much attention is given to ocean climates.

The next seven chapters are devoted to the climates of Europe, the West Indies and South America, the Mediterranean and the Middle East, Africa, Asia, Australia and the Pacific islands, and North America. The appendix includes five tables of climatological data and supplementary information on weather for ocean crossings. There is a general as well as a geographical index with chart references. All the photographs are good and many are striking, for instance, those of scarf clouds, waterspouts, crest clouds; their reproduction is adequate but not sharp.

Of undoubted use to those sailing or flying for foreign parts, this small compendium should also prove a convenient reference for those in commercial firms, and even for meteorologists who lack library facilities.

C. CHAPMAN
Blue Hill Meteorological Observatory

NAVIGATION

Lyman M. Kells, Willis F. Kern, and James R. Bland. McGraw-Hill Book Company, Inc., New York, 1943. 479 pages. $5.00.

THESE three professors of mathematics at the United States Naval Academy have written a splendid textbook. It treats of navigation as a whole, piloting, maneuvering, dead reckoning and celestial. The equipment of the navigator is described rather fully: the charts, instruments, the aids, lights, buoys, radio. The fundamentals of mathematics are, in this reviewer's opinion, too fully covered. There is a chapter on elementary trigonometry and the use of the slide rule; another on a review of spherical trigonometry; a third on logarithms, and even a short discussion of the mathematics involved in map projections.

There is a vast amount of good material in the book but it is scattered in its arrangement. The astronomy, like the trigonometry, crops up in several places. One complete chapter, of less total wordage, would have disposed of either subject, once and for all.

Some of the more practical phases of navigation are not sufficiently treated. One might, for instance, think that Comdr. Ageton had just discovered his method. The authors say: "Four methods of solving the astronomical triangle are known." A pilot chart of some years back listed a great many. There are more than four in regular service. They derive the Ageton formulas and one might think the method consisted of using those formulas. Nothing is said here about H. O. 211. They even give problems to work by the formulas. Dreisonstok's method is similarly treated. Not a word is said about

(*Continued on page 19*)

SKY-GAZERS EXCHANGE

GLEANINGS FOR A.T.M.s

Foucault Test for a Schwarzschild

Your discussion of the Schwarzschild camera in the January issue of **Sky and Telescope** prompted the following calculations for use of the Foucault test in figuring the mirrors. The calculations are straightforward and follow the standard pattern for reducing any curve to terms of knife-edge position.

Taking the two equations for the curves, the variables were interchanged to place the curves symmetrically about the X-axis, as ordinarily represented in Cartesian coordinates, and each variable term was divided by the focal length, f, of the completed camera, raised to the same power. At the same time, the two constants were dropped, as they only pertain to the distance between the mirrors as placed in the camera. The equations become (1):

$$\text{Primary: } x = -.1y^2/f + .0125y^4/f^3$$
$$\text{Secondary: } x = .3y^2/f + .12y^4/f^3$$

where x, y, and f are measured in any consistent set of units, inches being chosen here. With the constants dropped, the curves shift so that their vertices are at the origin, as shown in the sketch, and the problem resolves itself into finding the distances x_1 for the curves, where Px_1 is the normal to the curve at the point P. The distance x_1 is the distance of the knife edge from the center of the mirror for a zone whose radius is y_0. This is accomplished, first, by finding the equation for the normal Px_1 in terms of y_0, and then finding the x-intercept x_1 by setting $y = 0$ in the equation for Px_1. The equation for Px_1 is (2):

$$y - y_0 = -dx/dy\ (x - x_0).$$

Working this out for x_1, neglecting 4th powers and substituting for x_0 from equation (1), and simplifying, we have (3):

$$x_1 = f^3/(.05y_0^2 - .2f^2) - .1y_0^2/f$$
$$x_1 = f^3/(.48y_0^2 + .6f^2) + .3y_0^2/f$$

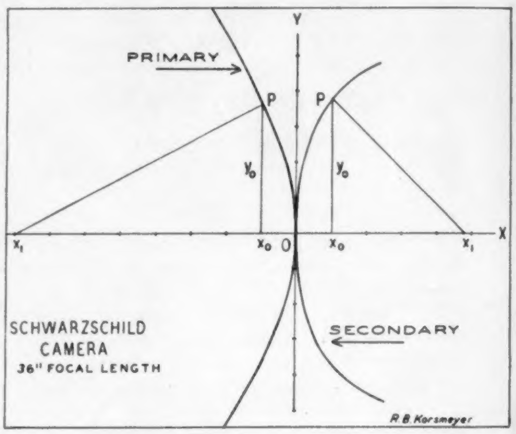
Using 7-place log tables, for a 36-inch focal-length camera, the knife-edge positions for every half-inch value of y_0 come out as follows:

Primary	Δx_1	y_0	Secondary	Δx_1
—180.000	+ .000	0.0	60.000	—.000
.010	.010	0.5	59.993	—.007
.037	.037	1.0	.971	—.029
.084	.084	1.5	.936	—.064
.150	.150	2.0	.885	—.115
.232	.232	2.5	.821	—.179
.338	.338	3.0	.744	—.256
.459	.459	3.5		
.602	.602	4.0		
.763	.763	4.5		
.942	.942	5.0		
—181.141	+1.141	5.5		
.359	1.359	6.0		

The values for the primary mirror are negative because the curve is drawn concave to the left, whereas the secondary mirror curve is concave to the right. Although the values are given to three places, the third decimal is of questionable accuracy, and should be rounded off.

It is apparent that the primary mirror is extremely "hyperbolic" as compared to a paraboloid of similar size and curvature. The secondary mirror approximates an oblate spheroid, as is evidenced by the knife-edge positions moving **nearer** the mirror for the outer zones. Although the oblate spheroid is a form of ellipsoid, it might be better not to call it that only (as was done in the article) because many persons think of an ellipsoid as the surface used for Gregorian secondaries, namely, a prolate spheroid.

Obviously, figuring these mirrors is a far more difficult task than figuring a corresponding paraboloid because of the relatively extreme changes in knife-edge position. Apparently, the only figure



which would be seen under the knife edge would be a bright, annular circle of light at the zone under test. A better test would be one which could show up the entire mirror at one time, and the Ronchi test modified to give quantitative measurements, described by J. H. King in **Amateur Telescope Making Advanced** (pages 104-108 in the 1937 edition) looks like the answer.

Another type of test which could be applied to the completed camera is an adaptation of the "slit" test often used in figuring the lens for a Schmidt camera. The test, as applied to Schmidts, is described by Franklin B. Wright (giving credit to Lower) at the bottom of page 407 in **A.T.M.A.** The modification would be to place the slit source of light at the focus of the camera and to direct it toward the secondary mirror. If the secondary is correctly figured, this test may be used to put the finishing touches on the primary. However, an extremely bright light source would be required for testing both mirrors before silvering.

Lest the above discussion be misleading as to my experience in mirror making, the facts are that I've made only one mirror, a 6-inch paraboloid of 46½-inch focal length. The first five stages of grinding were done last spring out of doors at the entrance to our two-room apartment. When the wind blew hard enough to raise dirt, the work was stopped until the dust subsided. The last two stages of fine grinding were done in the bedroom, and polishing and figuring in the living room.

Edited by Earle B. Brown

The mirror seems to be fairly satisfactory, having a resolving power of two seconds of arc, as compared to a theoretical limit of slightly under one second for a wave length of about 5000A.

R. B. KORSMEYER
718 So. Washington St.
Alexandria, Va.

ED. NOTE: As shown in the above computations, the focal lengths of primary and secondary mirrors of the Schwarzschild are, respectively, 5/2 and 5/6 times the equivalent focal length of the completed camera. The axial separation of the two mirrors is 5/4 times the same quantity, and the distance from secondary to image plane is 1/2 the equivalent focal length.

OCCULTATION REPORTS

(*Continued from page 2*)

moon, when I have seen them easily with binoculars on other occasions.

"A call to my husband for help in marking the time of immersion brought the sleepy reply that the seven o'clock whistles were just blowing! The two bodies were first tangent at approximately seven o'clock, but the entire disk was not hidden until more than a minute later.

"Although the occultation was predicted as over an hour, I looked every five minutes at the inscrutable moon which gave no hint of concealing the mighty Jupiter behind her back. Sunlight shining on one of the peaks on the terminator looked like the planet peeking out until I realized that Jupiter would reappear in the darkness a slight distance away from the terminator, at the actual edge of the gibbous moon.

"At a couple of minutes after eight o'clock, I observed the slow reappearance of Jupiter. Despite an increased understanding of the ways of the heavenly bodies, I breathed a sigh of relief with the ancients that the 'tiny' Jupiter had not been swallowed up by the 'mammoth' moon."

Down Texas way the occultation was "blacked out" by clouds, according to the February issue of the **Texas Observers' Bulletin,** edited by Oscar E. Monnig, of Ft. Worth. He says: "We have had no reports, but doubt whether skies were clear at any point in the state on that morning with the possible exception of the El Paso region. On the next morning it was clearing at Ft. Worth and the phenomenon would have been easily seen —just 24 hours late!"

In the January issue of his bulletin, Mr. Monnig calls attention to a special feature of the occultation as it would have been seen in Texas. "Jupiter will have an equatorial diameter of almost 44", and the time required for its immersion will be on the order of several minutes. It would be about 1½ minutes if the position angle of immersion were 90°, but Jupiter will be near the southern tip of the moon with the occultation almost grazing, and the 'sliding effect' becomes rather drawn out in point of time in such a case." Too bad it was cloudy in the southern states!

Willis Blanchard, of Bangor, Me., writes: "I wish to report that I witnessed the eclipse of Jupiter on the morning of January 13th and enjoyed a perfect view until the sunshine prevented any further observation. I used 8-power binoculars for closeup views and very much regret that I couldn't photograph the celestial event. The sky was exceptionally clear and devoid of the haze that occurs on some frosty mornings."

In the nation's capital, Dr. Edgar W. Woolard, president of the National Capital Amateur Astronomers Association, observed the immersion with a 2-inch refractor, weather conditions being perfect.

From **Astronomical Information Sheet** No. 114, compiled by the Astronomical Information Service, 1059 Sierra St., Reno, Nev., we note that Dr. Charles D. Humberd, of Barnard, Mo., used a power of 96 with his 4-inch refractor, but that his "seeing was poor with 'bad atmospheric turmoil' and Jupiter's satellites were seen only by glimpses."

This same publication calls attention to the fact that observers in California and Nevada, who had only a conjunction of the moon and Jupiter in January, were to see a Jupiter occultation of their own, by the practically full moon, on February 9th in the early morning.

BOOKS AND THE SKY

(*Continued from page 17*)

the way a navigator works the method—H. O. 208.

The book is well illustrated. A great many official Navy photographs add a touch that no other book has, pictures on the bridge and in the chart room, pictures of various types of craft. However, a goodly number of poster-like pictures from the recruiting bureau, commercial concerns, and the like, add little to the book. They bear no captions. If the authors do not take the trouble to fit a picture into the story, the reader is not likely to do so.

There are several hundred good problems to solve, and the answers are given. A sense of reality is given each problem, even the most elementary. A vessel is not just a "ship"; it is a cruiser in a task force. A lighthouse has a name; illustrations are referred to specifically to show the types of craft mentioned. Navigation is not something to read about, but something to do. When a student works all these problems he should know about navigation.

I wish we could all get together on which way time diagrams should go. Dutton and Bowditch draw west counterclockwise, but these authors prefer to make it clockwise. Also the spelling of **sidereal**! I still say the book is good in spite of the critical remarks here. It is well written, amply illustrated, and a good-looking job. It is written by Navy men and has a distinct Navy tang. This is important, especially in the early stages of learning. The student not only learns the facts but catches the spirit of a subject from such a book as this.

WILLIAM H. BARTON, JR.
Hayden Planetarium

In Focus

PLATO, dark-floored ringed plain, is the center of attraction of this month's lunar landscape on the back cover; with this picture is concluded the series of four detailed photographs of the moon. These were all originally enlarged directly from a single negative taken by the Lick Observatory, and reproduced by courtesy of that institution. Plato is 60 miles in diameter, with walls rising an average of 3,000 to 5,000 feet above the interior.

The principal features of the other three scenes were Tycho and Clavius, the Apennines, and the ray-centered crater Copernicus.

In the upper left corner, the large crater with a smaller one inside it is Cassini; extending from Cassini to Plato are the lunar Alps, with 14,000-foot Mt. Blanc 2¼ inches from the left edge and 3½ inches from the top. Extending to the left just below it is the great Alpine Valley, about 75 miles long and from four to six miles wide. To the right of Cassini is the isolated peak, Piton, and above Plato is isolated Pico.

Mare Frigoris extends across the picture below (to the north of) Plato, and below this are the mountains around the moon's north pole. Anaxagoras is the crater two inches from the left edge and 1½ inches from the bottom. To the left of it is Goldschmidt, through which the moon's central meridian passes.

The discussion of the apparent inversion in photographs of lunar craters is still going on, with no definite solution in sight. Peter A. Leavens, of Oceanside, N. Y., states that he can't see the inversion at all, possibly because he has spent so much time observing and photographing Luna.

Amateurs in Dayton, Ohio, have been watching the moon, too. Concerning the inversion, in January DeWitt Saunders sent a clipping from **Life** magazine of animal tracks in the sand; there, as in the bomb craters, orientation of the picture seems to be the determining factor. G. F. Hofferberth, treasurer of the Dayton Astronomical Society, observed the moon occult Jupiter on January 13th, and sent in times of the contacts obtained with a stop watch and a 12-inch reflector.

Navigation Star Pronunciations

By Samuel G. Barton, *University of Pennsylvania*

THE REPORT prepared by the Committee of the American Astronomical Society on Preferred Spellings and Pronunciations includes a list of 50 important special star names. This report was published in **Popular Astronomy,** August, 1942, and in **Sky and Telescope,** June, 1943. Since its appearance I, as chairman, have had numerous requests for the pronunciations of names of stars not included in that report, especially for the missing names among the so-called navigational stars of the **American Nautical Almanac** and of the **American Air Almanac.**

Mr. George A. Davis, Jr., of Buffalo, N. Y., also a member of the committee, and I have co-operated in the preparation of recommendations, based upon the same general plan, for a much longer list of stars. Such a list recently appeared in connection with an article by Mr. Davis in **Popular Astronomy,** and a nearly identical list in the new, third edition of Barton and Barton, **A Guide to the Constellations.** The article by Mr. Davis includes as its chief feature a detailed discussion of the origin of the names of the stars based upon the original sources. This valuable piece of research is the work of Mr. Davis alone.

In the accompanying table I give the names of the 50 navigational stars which are assigned special names, just as they are given on the back cover of the most recent issue of the **American Air Almanac,** with our recommendations for the pronunciation of the names thus given.

In our lists, however, we give Betelgeuse, Eltanin, Mirfak, and Rasalhague as the spellings for the corresponding names in the **Almanac** and correspondingly modified pronunciations. My list includes Al Na'ir, Al Suhail, and Dschubba, but only because they appear in the **Almanac.** Suhail is the well-known Arabic name of Alpha Carinae (Canopus). It is not properly the name of any other star and the name of Al Suhail should not be applied to Lambda Velorum. Al Na'ir and Dschubba are not regarded as legitimate and well-known star names. Acrux is questionable. The name Peacock (applied to Alpha Pavonis) is so absurd as a star name that we give it no recognition whatsoever. We believe that it is found nowhere except in recent governmental publications and in discussions closely related thereto.

In present usage Argo and Scorpio are incorrect as the names of constellations. The former constellation Argo is now replaced by four constellations, Carina, Puppis, Pyxis, and Vela, and the International Astronomical Union has recommended that Argo be dropped as a constellation. The second name should be spelled Scorpius.

From an engraving originally appearing in "The Ensign."

HERE ARE THE *preferred* PRONUNCIATIONS

Name	Pronunciation	Name	Pronunciation
Acamar	ā'kȧ-mär	Enif	ĕn'if
Achernar	ā'kẽr-när	Etamin	ĕ-tā'mĭn
Acrux	ā'krŭks	Fomalhaut	fō'măl-ôt
Adhara	ȧ-dā'rȧ	Hamal	hăm'ăl
Aldebaran	ăl-dĕb'ȧ-răn	Kaus Australis	kôs ôs-trā'lĭs
Alioth	ăl'ĭ-ŏth	Kochab	kō'kăb
Al Na'ir	ăl nār	Marfak	mär'făk
Alnilam	ăl-nī'lăm	Markab	mär'kăb
Alphard	ăl'färd	Miaplacidus	mī"ȧ-plăs'ĭ-dŭs
Alphecca	ăl-fĕk'ȧ	Mizar	mī'zär
Alpheratz	ăl-fē'răts	Nunki	nŭng'kē
Al Suhail	ăl sōō-hāl'	Peacock	pē'kŏk"
Altair	ăl-tār'	Polaris	pō̇-lā'rĭs
Antares	ăn-tā'rēz	Pollux	pŏl'ŭks
Arcturus	ärk-tū'rŭs	Procyon	prō'sĭ-ŏn
Bellatrix	bĕ-lā'trĭks	Rasalague	rȧs"ăl-ā'gwē
Betelgeux	bĕt'ĕl-jū̇z	Regulus	rĕg'ū̇-lŭs
Canopus	kȧ-nō'pŭs	Rigel	rī'jĕl
Capella	kȧ-pĕl'ȧ	Rigil Kentaurus	rī'jĭl kĕn-tô'rŭs
Caph	kăf	Ruchbah	rŭk'bȧ
Deneb	dĕn'ĕb	Sabik	sā'bĭk
Deneb Kaitos	dĕn'ĕb kā'tōs	Shaula	shô'lȧ
Denebola	dĕ-nĕb'ō̇-lȧ	Sirius	sĭr'ĭ-ŭs
Dschubba	jŭb'ȧ	Spica	spī'kȧ
Dubhe	dŭb'ē	Vega	vē'gȧ

Key to Pronunciation: āte, ȧcation, căt, finăl, ȧsk, commȧ, câre, stär; bē, ē̇vent, pĕt, novĕl, readẽr; tīme, bĭt; bōne, ō̇bey, hŏt, lôrd; mōōn; ūse, ū̇nite, sŭn, focŭs.

A PIVOTAL STAR

EVERYONE will admit that Polaris is the most important **accidental** star in the heavens; but no one seems to have noticed that there is another accidental star that stands only second to Polaris. I think historians feel that the pole star, "the cynosure of all eyes, the observed of all observers," has accomplished a great deal for navigation and history. However, as a matter of astronomical interest the star of which I now speak runs a good second.

Let the reader go out under the unclouded sky when Orion is on the meridian and make this observation. Fix the eye on Epsilon Orionis, central star of the Belt. Draw an imaginary line, a short one, from Delta to Zeta. Then draw another from Bellatrix to Saiph. Count two. To the northeast of Bellatrix is 3rd-magnitude Lambda, from which draw a line through Epsilon to Alpha in Lepus. Count three. On the line from Betelgeuse to Rigel, count four. You have now only begun.

Look higher to Aldebaran, the red star, and draw a long line through Epsilon Orionis to Sirius, the most brilliant star. These experiments alone make Epsilon unique, but there is still another spoke to this remarkable wheel. Overhead is Capella, a star in color and temperature like our sun. Take two steps now instead of one, because of the length: draw your line to Epsilon, then keep right on down to the southern horizon but do not stop there. Continue five or 10 degrees (depending on your latitude) below the horizon and you will reach Canopus, second only to Sirius in brilliance. I once had the pleasure of seeing it as I was entering Needles, Ariz., and Dr. Robert G. Aitken once caught sight of it, from the Lick Observatory, just over the edge of the Santa Cruz Mountains.

GEORGE D. BAIRD
San Francisco, Cal.

DEEP-SKY WONDERS

THIS month finds the following objects in good position for observation with moderate-sized telescopes. Descriptions are from Norton's **Star Atlas.**

Ursa Major. M81, 9^h $51^m.5$, + 69° 18′, appears bright with an almost stellar nucleus grouped with small stars. It is a spiral with rather faint arms. Included in the field with very low power is M82, 9^h $51^m.8$, + 69° 58′, an almost edgewise spiral, appearing as a narrow curved ray, 7′ x 1½′.

Puppis. M46, 7^h $39^m.5$, —14° 42′, which is a beautiful cluster of small stars, about 30′ in diameter. On its northern edge is the irregular planetary ring nebula NGC 2438. Another planetary nebula in Puppis is NGC 2440, 7^h $39^m.6$, —18° 5′; it is bluish, in a rich neighborhood, best seen with a moderately high power, and followed by a ruddy 10th-magnitude star.

CORRECTION TO THE CHART

The star Bellatrix, in Orion, is labeled Beta instead of Gamma.

STARS FOR MARCH

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern war time.

Color Contrasts in Neighboring Stars

THE ACTUAL color of a star can best be detected by comparison with a neighbor of an entirely different hue. With my refracting telescope, for example, the red stars do not appear entirely red, but seem to be yellow with streamers of red which might cause the beginner to feel that atmospheric refraction is responsible. If the telescope is trained on a truly yellow star, the difference is noticed immediately because of the lack of any sign of a reddish tinge. Where it is possible to observe two stars in the same field, as in the case of visual double stars, the companions of which are often of different colors, the contrast is very noticeable. The two very well-known doubles, Gamma Andromedae (Almach) and Beta Cygni (Albireo) are each composed of an orange star, spectral class K0, and a white star, spectral class A0. Since the latter is on the border line between the blue and white divisions, a very faint bluish tinge might be noticed which to some eyes appears as pale green. But the orange color of the K0 star will stand out in sharp contrast.

When Regulus was in conjunction with and very close to the moon at our local station on May 12, 1943, many persons remarked that it seemed so very blue and more so than they had ever noticed it before. The star belongs to spectral class B8, making it blue-white, but its contrast with the yellow moon accentuated the blue tinge and it appeared as a brilliant aquamarine.

The following are the principal spectral classes with the color and approximate surface temperature of each group:

Spectral Class	*Color*	*Temperature* (Fahrenheit)
O	Blue	Above 41,000°
B0 to B9	Blue to blue-white	41,000°—20,000°
A0 to A9	White	20,000°—13,000°
F0 to F9	Pale yellow	13,000°—11,000°
G0 to G9	Yellow	11,000°— 9,000°
K0 to K9	Orange	9,000°— 6,000°
M0 to M9	Red	6,000°— 5,400°

There are variations from this scale of temperatures depending on whether a star of late spectral class is a giant or a dwarf, but for our purposes this variation is unimportant and does not change a star's color noticeably.

One of the many interesting pastimes for the owner of a good pair of binoculars or a small telescope is the observation of the color in stars. After some practice, the observer will not only be able to differentiate among the lettered groups, but will also find he can tell within two or three numbers in what part of the class the star belongs. In the **American Ephemeris and Nautical Almanac** for 1940 or earlier, the spectral classification is given for more than 900 stars. In the more recent editions this number has been reduced to about 200. This classification is also included in the **Catalog of 3539 Zodiacal Stars for the Equinox 1950,** which may be obtained by sending 30 cents to the Superintendent of Documents, Washington, D. C. These two lists will cover sufficient stars to give the amateur plenty of practice in this branch of astronomy. For spectral classes and other information about all stars brighter than magnitude 6.5, the **Catalogue of Bright Stars** may be purchased for $3.00 from Yale University Observatory, New Haven, Conn.

The pairs of stars near to one another on which I shall comment in the subsequent paragraphs cover in general the extreme cases of the hot blue and white classes as compared to those that are cool and red. In order to become familiar with all classes, the observer should sweep the field of a constellation until a star appears that is outstanding from its neighbors as, say, blue, orange, or red. Then a reference to the lists I have noted will show it to be of spectrum B1, K5, or M0, as the case may be.

Beta Persei (Algol), class B8, and its neighbor two degrees to the south, Rho Persei, M3, make an excellent pair to begin with; they may be seen during a majority of the months of the year in mid-northern latitudes. Other pairs that are high in the northern skies at this season are the Pointers of the Big Dipper, Merak, A0, and Dubhe, K0. The Alpha and Iota stars in Draco have these same respective classifications, while the two stars in the Little Dipper that correspond to the Pointers in the Big Dipper are A2, Gamma, and K5, Beta.

In our summer skies, the Alpha stars in Ophiuchus and Hercules, Rasalhague, A5, and Rasalgethi, M3, are close neighbors. The latter is probably the largest naked-eye star. Also, Beta and Sigma, both B1, in Scorpius, are in contrast with Antares, M0. Spica, B2, is near Delta Virginis, M0, and Beta Librae, B8, shows very blue compared with Sigma Librae,

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES

In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 8:30 p.m. on the 7th and for 7:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury will be in superior conjunction with the sun on the 17th, and so too close to the latter for observation until the end of the month, when careful watch may reveal it setting an hour after the sun.

Venus is in Capricornus and Aquarius, but rising only shortly ahead of the sun; it is approaching the full phase and has little observational interest.

Earth will arrive at heliocentric longitude 180° at 1:49 p.m., March 20th, so the sun will appear at the vernal equinox, in the constellation Pisces which it entered on March 11th.

Mars, in Taurus, will be in conjunction with and 3° 25′ north of Saturn on the 7th, the two planets appearing about equally bright. It will be 1° north of the center of the open cluster M35 on March 30th.

Jupiter, brightest object in the evening sky except for the moon, will be in retrograde (westward) motion in Leo, increasing its distance from Regulus. The moon passes near Jupiter on the 7th.

Saturn will be 90° from the sun on the 10th, and in conjunction with Mars three days earlier.

Uranus is in Taurus also; see article and diagram in the January issue.

Neptune is in Virgo; see article and diagram last month.

M3. Alpha Coronae Borealis and Mu Serpentis are hot and white when compared to Beta Herculis, K0, and Delta Ophiuchi, M0. Farther south, Epsilon, A0, and Eta, M3, in Sagittarius make a good pair for observation. Epsilon, B5, and Gamma, G5, in Delphinus, and Deneb, A2, and Epsilon Cygni, K0, are neighboring pairs.

The fall and winter skies produce such interesting contrasts as Markab, A0, and Scheat, M0, in the Great Square of Pegasus; Pi, B3, and Delta Andromedae, K2; Mu Andromedae, A2, and Beta, M0. In Cetus are many red stars, including Mira, M7, the long-period variable that will be at maximum during the early part of March, and Alpha Ceti, M0. A few degrees southwest of Mira are five bright K0 stars: Beta, Eta, Theta, Zeta, and Tau Ceti; but Gamma and Delta Ceti are A2 and B2, respectively.

In Gemini, the Nu star, B5, contrasts strongly with Eta and Mu, each M0, while Castor, A0, and Pollux, K0, are twins in name but not in color. A little farther along the zodiac, Regulus, B8, and Pi Leonis, M0, are worth observing. Betelgeuse, M0, in Orion, shines alone as a cool, red star in comparison with Rigel, B8, Bellatrix, B2, Delta, Epsilon, Zeta, and Kappa, all B0, and Iota, an O star which is bluer and hotter than any of the B stars.

This survey must surely include the bottom and top stars in the Southern Cross, Alpha, B1, and Gamma, M3. Alpha is a binary and both components are hot, blue stars, as is also Beta Crucis.

PHASES OF THE MOON

First quarter	March 1, 4:40 p.m.
Full moon	March 9, 8:28 p.m.
Last quarter	March 17, 4:05 p.m.
New moon	March 24, 7:36 a.m.
First quarter	March 31, 8:34 a.m.

OCCULTATIONS FOR TEXAS

PREDICTIONS are for longitude 98° 0'.0 W., and latitude 30° 0'.0 N. The data include: date, name of star, magnitude; G.C.T. in hours and minutes, **a** and **b** quantities in minutes, and position angle in degrees, at immersion; G.C.T., **a** and **b** quantities, and P.A., at emersion.

Mar. 3, BD +19° 1110, 6.0; 4:08.8, —1.7, —1.9, 112°; 5:24.6, —1.4, —0.2, 250°.

Mar. 3, 57 Ori, 5.9; 5:53.6, —0.2, —3.3, 140°; 6:40.2, —1.1, +0.8, 226°.

Mar. 14, 13 Lib, 5.8; 12:12.3, —2.5, +0.3, 65°; 13:10.2, —1.3, —3.3, 337°.

Mar. 15, Gamma Lib, 4.0; 5:55.4, 0.0, —0.9, 146°; 6:53.4, —1.4, +1.3, 264°.

Mar. 15, Eta Lib, 5.6; 11:47.0, —2.2, —1.6, 125°; 13:12.8, —1.9, —1.0, 273°.

Mar. 19, 253 B Sgr, 6.0; 11:21.2, —1.3, +0.1, 115°; 12:35.0, —2.3, +1.2, 248°.

Mar. 31, 16 Gem, 6.1; 3:46.7, —1.0, —2.0, 115°; 4:55.9, —0.9, —0.6, 258°.

The predictions, computed voluntarily by Miss Tecla Combariati and J. Lynn Smith, of the U. S. Naval Observatory, are similar in form to those given in the **American Ephemeris** for 1944, pages 365-372.

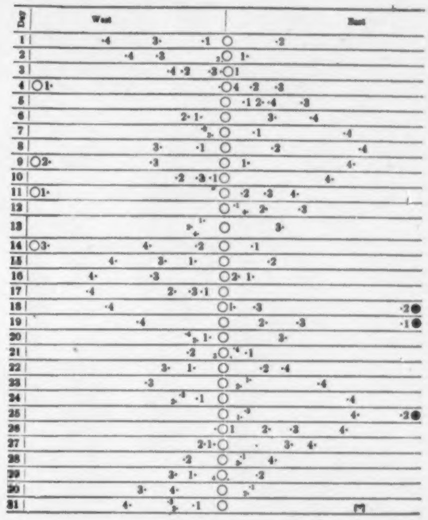
MINIMA OF ALGOL

March 7, 3:29 a.m.; 10, 0:18 a.m.; 12, 9:07 p.m.; 27, 5:14 a.m.; 30, 2:03 a.m.

JUPITER'S SATELLITES

Throughout the evenings of March 2nd, 16th, and 30th, the four moons will be west of Jupiter, and on the 4th and 10th they will be on the east side. On the 10th and 30th, they will be in numerical order, with **I** nearest the planet.

Jupiter's four bright moons have the positions shown below at 1:00 a.m., E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris**.



OCCULTATIONS — MARCH, 1944

Local station, lat. 40° 48'.6 north, long. 4^h $55^m.8$ west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Mar. 3	6.0	BD +19° 1110	0:30.0 a.m.	53°	1:23.3 a.m.	310°
3	5.9	57 Orionis	1:41.2 a.m.	78°	2:38.6 a.m.	285°
6	5.6	Theta Cancri	2:52.0 a.m.	118°	3:55.4 a.m.	275°
15	4.0	Gamma Librae	2:18.3 a.m.	77°	3:22.6 a.m.	334°
30	6.1	16 Geminorum	11:56.2 p.m.	52°	0:43.3 a.m. (31)	318°
31	4.1	Nu Geminorum	0:23.2 a.m.	116°	1:17.5 a.m.	254°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents, *March 1st to 22nd,* LIFE ON OTHER WORLDS.

The earth is one of nine major planets known. With our world teeming with such a variety of life, both plant and animal, a question of perennial interest is whether or not the eight other worlds of our solar system are fitted for life. This question, not so many decades ago, was a futile one for the astronomer to attempt to answer. But the invention of revolutionary and sensitive instruments reveals physical conditions before unknown. Now planetary temperatures can be found. Delicate tests have been devised for detecting the composition of planetary atmospheres. The resulting data provide a more solid basis for speculations regarding life on those eight known worlds. This show presents the latest discoveries concerning their habitability, and also concerning the possibility of there being other planets in the universe, conceivably inhabited, which remain to be discovered.

March 23rd to April 10th, THE STORY OF EASTER.

★ **THE HAYDEN PLANETARIUM** presents in *March,* OUR PLANETARY NEIGHBORS. (See page 4.)

In *April,* STARS OF SPRING. With a camera we scan the spring sky. The stars have changed since January; we can check off certain groups and add new ones. These stars, too, are guides to the navigator. And in our quick study of the spring sky, we shall not miss the stars which guide the planes over the southwest Pacific; to them, these are stars of autumn.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays (except Tuesdays) ....3 and 8:30 p.m.
Sundays and Holidays ....3, 4, and 8:30 p.m.
(Building closed Tuesdays)

★ STAFF—*Director,* Arthur L. Draper; *Lecturer,* Nicholas E. Wagman; *Manager,* Frank S. McGary; *Public Relations,* John F. Landis; *Chief Instructor of Navigation,* Fitz-Hugh Marshall, Jr.; *Instructor, School of Navigation,* Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ....2, 3:30, and 8:30 p.m.
Saturdays ....11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays ....2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator,* Clyde Fisher; *Curator,* William H. Barton, Jr.; *Associate Curator,* Marian Lockwood; *Assistant Curator,* Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant,* Fred Raiser; *Lecturers,* Charles O. Roth, Jr., Shirley I. Gale, John Saunders.